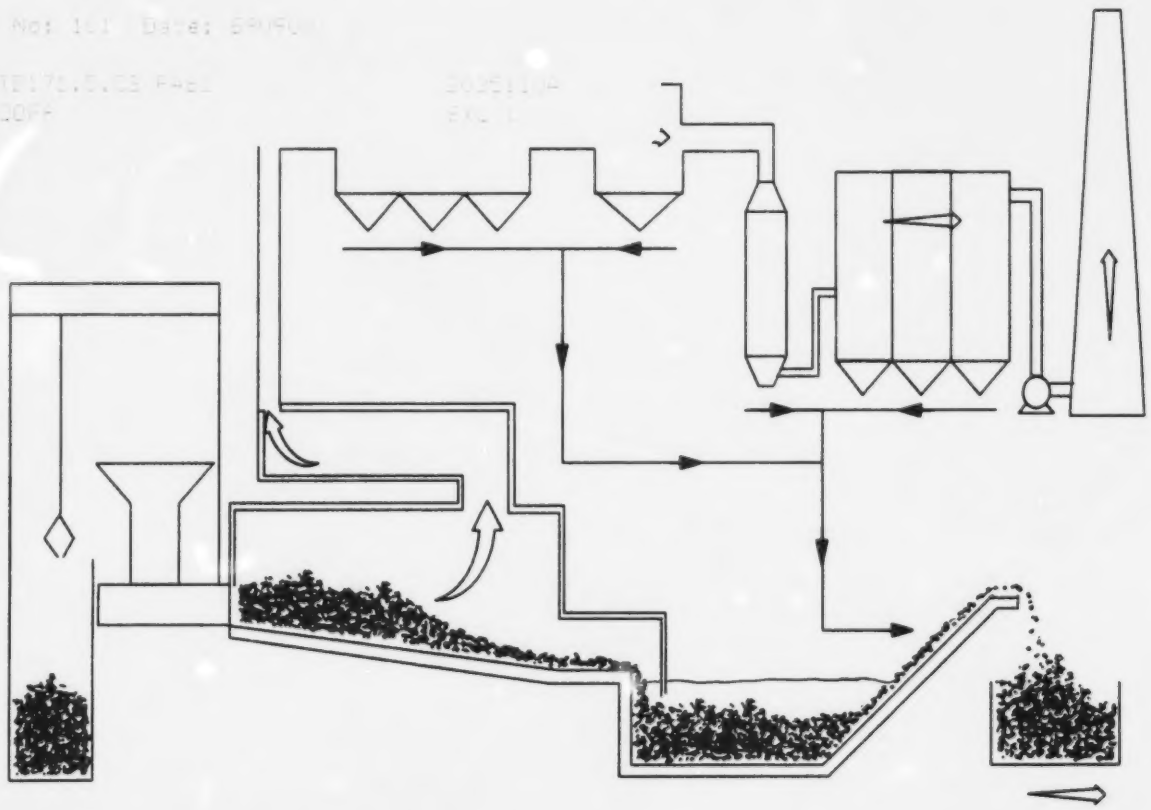
The National Incinerator Testing and Evaluation Program

CHARACTERIZATION OF RESIDUES FROM A MODULAR MUNICIPAL WASTE INCINERATOR WITH LIME–BASED AIR POLLUTION CONTROL



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THE NATIONAL INCINERATOR TESTING AND EVALUATION PROGRAM: CHARACTERIZATION OF RESIDUES FROM A MODULAR MUNICIPAL WASTE INCINERATOR WITH LIME-BASED AIR POLLUTION CONTROL

by

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1.0 INTRODUCTION

In 1984, Environment Canada established the National Incinerator Testing and Evaluation Program (NITEP) to examine the impact of municipal waste incineration on the environment and human health. Under NITEP, the Wastewater Technology Centre initially evaluated the chemical properties and leachability of residues collected from two different types of municipal solid waste (MSW) incinerator systems and an air pollution control pilot plant, using a battery of laboratory tests (Bridle and Sawell, 1986; Sawell et al. 1987; Sawell and Constable, 1988). Based on the results from these and other studies, concern was expressed by government agencies and environmental groups over the potential release of toxic substances from improper disposal of MSW residues. This resulted in an expansion of the scope of the NITEP ash characterization studies to include the evaluation of ashes from several other different incinerators in Canada and the U.S. The first study in this expanded program evaluated ashes from a coarse refuse derived fuel (semi-suspension) combustion system (Sawell et al., 1989). This report describes the results of the second study in the expanded program, which evaluated bottom, boiler, economizer and combined conditioning tower/fabric filter (CT/FF) ash from the London Victoria Hospital (LVH) Energy-From-Waste Facility in London, Ontario.

1.1 London Victoria Hospital Energy-From-Waste Facility

The facility, which is owned and operated by London Victoria Hospital, provides steam and electricity to the various buildings which make up the hospital complex. It has been in full operation since the spring of 1988 and consists of three parallel incinerator units, each one designed to handle about 75 to 90 tonnes of municipal and light refuse per day. No commercial, medical or pathological waste is processed through this facility. The incinerators are classified as two-stage or modular combustion systems. The lime-based air pollution control systems consist of water spray conditioning towers and fabric filter dust collectors.

A cross section schematic of the system is shown in Figure 1. Unprocessed refuse is fed from a feed hopper into the oxygen starved primary combustion chamber via a loader ram. Transfer rams move the refuse down the bed of the primary chamber and discharge the ash into a quench tank, which also acts to seal the unit. The resulting

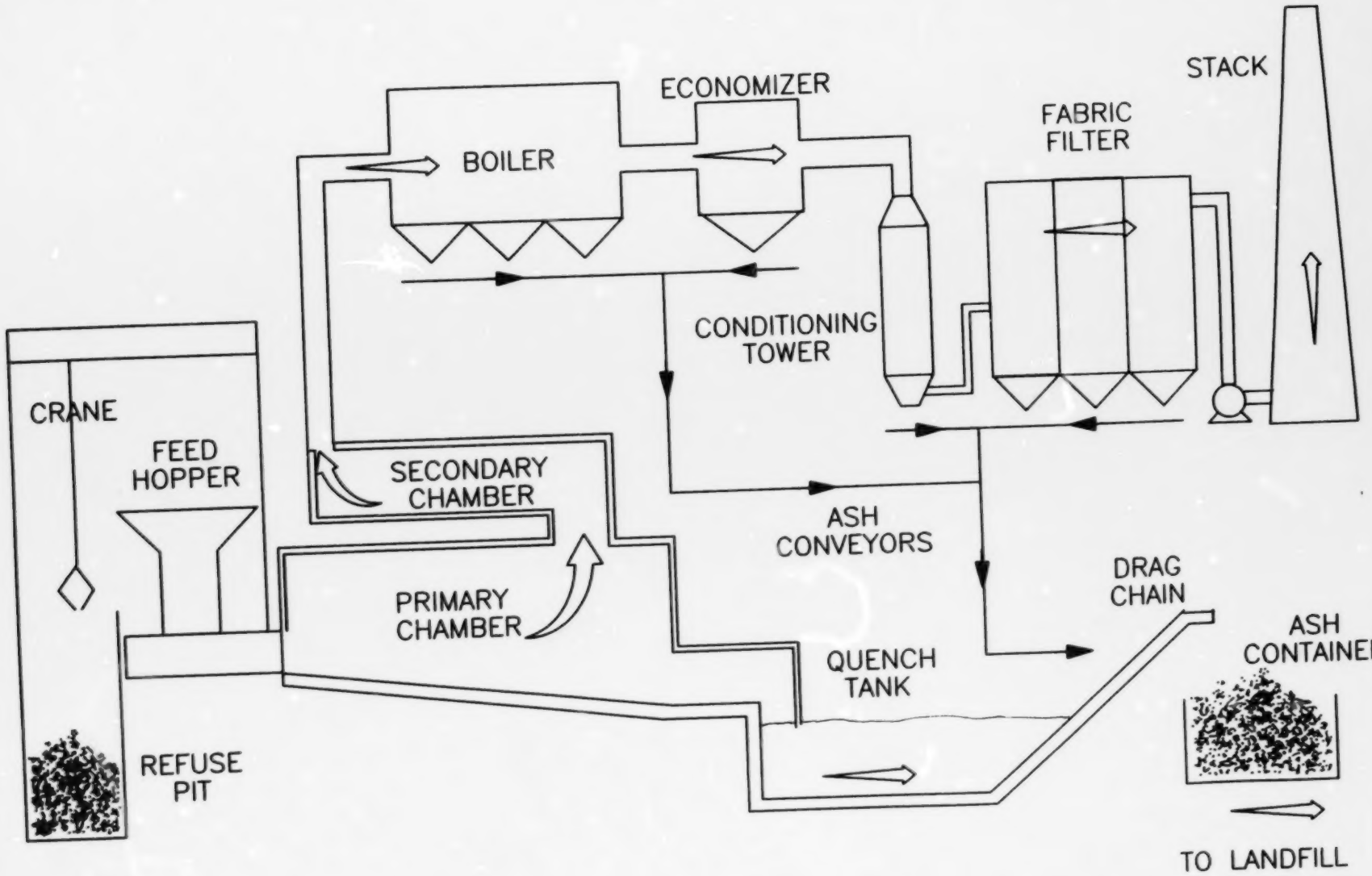

FIGURE 1. CROSS SECTION SCHEMATIC OF THE LVH–EFW FACILITY

bottom ash is removed from the quench tank via a drag chain unit which conveys the residue to ash storage bins for transport to the landfill.

Typically, the temperature in the primary chamber is just above 800°C. The fuel rich flue gases produced from this semi-pyrolytic process then flow into a highly oxidative, high temperature secondary combustion chamber. The temperature in the secondary chamber generally ranges from 1000 to 1150°C. The combusted flue gases then pass through the boiler and economizer heat recovery units before entering the spray conditioning tower, where they are humidified and cooled by a fine water spray. Dry lime is then injected into the gas stream prior to it passing through the fabric filter or baghouse units where fine particulates (down to submicron particle size) are removed. Fly ash, captured in the boiler, economizer, conditioning tower and fabric filter units, is transported via screw conveyors and dumped onto the quench tank drag chain conveyor which combines it with the bottom ash. Note that although Figure 1 only shows a single screw conveyor leading from the boiler and economizer units, there is a separate screw conveyor for each unit.

1.2 Sample Collection

Ashes were collected from one of the three incinerator units, over a five day period, in the spring of 1988. A summary of the operating conditions is given in Appendix 1. Four individual ash streams were sampled, namely, bottom ash, boiler ash, economizer ash and CT/FF ash. Prior to the sampling period, the incinerator used in this study was shut down for maintenance and cleaning. In addition, the quench tank was drained and cleaned, then re-filled with fresh water. The individual ash streams were then isolated from one another and sampling ports were fitted onto each of the ash transport systems. For example, the drop chute from the boiler ash screw conveyor was blocked off just above the point where it connects with the common screw conveyor leading to the drag chain chute. 10 cm sampling ports were cut into the bottom of the economizer and conditioning tower/fabric filter conveyors.

Quenched bottom ash was sampled from the ash storage bins. A small shovel (about 15 x 15 cm blade size) was used to collect the grab samples, which were taken once every 2 hours and composited in 20 litre buckets (one bucket per 24 hour period) over the five day sampling period. Each of the daily composite samples were cored

using a 10 cm diameter stainless steel soil sampler, then passed through a 9.5 mm sieve. Some size reduction was required on a small portion of material to insure that the entire sample passed through the sieve. The five core samples were then composited and allowed to dry in a vented drying oven at 35 to 40°C for 36 hours prior to being mixed using a Brinkman PT Sample Mixer. The resulting mixed sub-samples were used for testing and analyses. One sub-sample was stored in a glass container at 4°C for organic analyses and testing.

Sampling of representative boiler and economizer ash streams on a continuous basis was not possible with the plant configuration, since sufficient ash could not be collected in the hoppers prior to sampling to form a pressure seal for the system. Consequently, ash in the hoppers was drawn back into the system when the sampling port was opened, due to the draft created by the negative pressure within the boiler/economizer units. The problem was solved by allowing the ash to accumulate in the hoppers over the 5 day test period by shutting down the screw conveyors leading from the hoppers. On the final test day, the conveyors were turned on and all of the accumulated ash (49 kg of boiler ash and 10 kg of economizer ash) was collected in 200 litre drums. Since only a small quantity of each ash was collected, samples were obtained from the respective drums by taking cores using the collection jars. These samples were then mixed using a Brinkman PT Sample Mixer. One of the resulting mixed sub-samples from each type of ash was collected in a glass container and stored at 4°C for organic analyses and tests. The other sub-samples were stored in polyethylene bottles and used for inorganic analyses and tests.

Combined ash from the conditioning tower and fabric filter unit was collected on a continuous basis over the five day test period, by allowing the ash from the common screw conveyor to drop through a 10 cm sampling port into 200 litre drums. The time required to fill a drum was dependent on the operating conditions which are discussed in Appendix 1. One core sample from each full drum was taken using a 7.5 cm diameter stainless steel soil sampler and placed in a separate container. In order to obtain a single sample, each of the separate containers was then cored three times using a 1.5 cm diameter glass tube (the sub-sample designated for organic analyses and testing was cored four times to provide a sufficient volume of sample required for analyses) and the cores were composited and mixed with a Brinkman PT Sample

Mixer. The mixed sub-samples were used for analyses and testing.

Since the lime injection ports malfunctioned during the last day and a half of testing, only CT/FF samples from the first three and a half days were used for test purposes. Further details are provided in Appendix 1.

2.0 ANALYTICAL AND TEST METHODS

An outline of the various tests and analyses performed during this study are shown in Figure 2.

2.1 Chemical Composition

The digestion methods for the solid samples varied according to the metal being analyzed. For Sb, B, Cd, Cr, Co, Cu, Pb, Ni and Zn analyses, samples were digested using aqua regia/hydrofluoric acid and peroxide. The digested solid samples and the leachates from the sequential batch extraction test were analyzed using DC plasma spectroscopy, flame atomic absorption (AA) or flame AA with graphite furnace. Different digestion methods and analytical techniques were used to measure Al and As in the solid samples. Analytical capabilities did not permit chloride and sulphate analyses on the solid samples, however, the leachates were analyzed for these parameters.

The ashes and the leachates from the sequential batch extraction procedure were also analyzed at Environment Canada's River Road Laboratory for the following organic compounds: poly-chlorinated dibenzo-p-dioxin (PCDD), poly-chlorinated dibenzofuran (PCDF), poly-chlorinated biphenyl (PCB), poly-nuclear aromatic hydrocarbons (PAH), chlorophenol (CP) and chlorobenzene (CB). A detailed account of the analytical methods used is given in Volume II of the 1987/88 series of NITEP reports (Environment Canada, 1987).

2.2 Total and Fixed Solids Content

The total solids content of each ash was determined, in duplicate, by weight loss of a sample at 104°C for 24 hours (ASTM Method D2216-71). The fixed solids content (performed in duplicate) was based on the weight loss of a dry sample after 1 hour at 550°C (APHA Standard Method 209E).

2.3 Acid Neutralization Capacity

The acid neutralization capacity test used in this study was a modified ASTM Method C400-64, which involved mixing 1 g of ash in 20 mL of distilled water with a magnetic stirrer and titrating the slurry until an endpoint pH of 4.4 was maintained

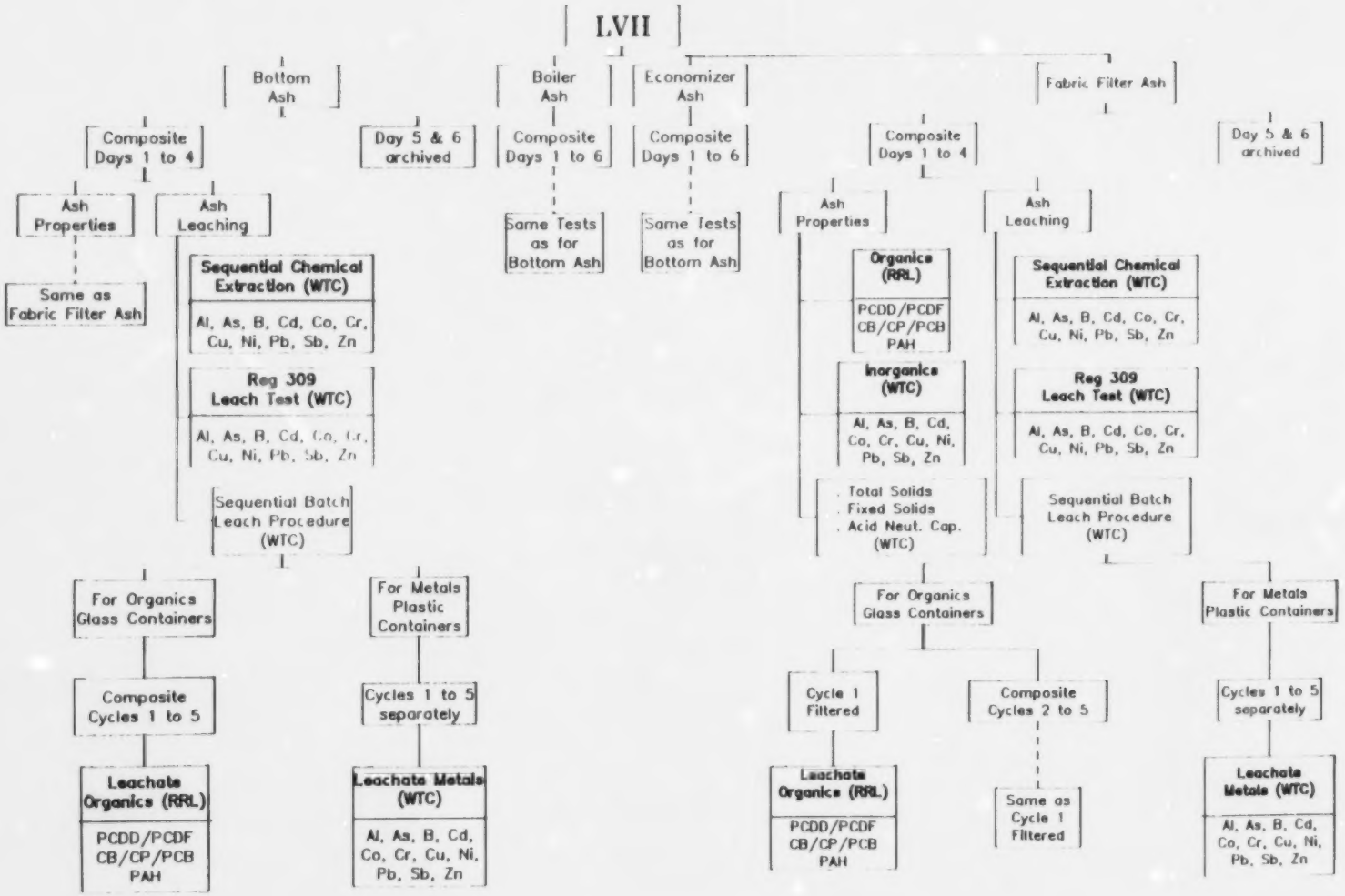
LVH
Bottom Ash
Boiler Ash
Economizer Ash
Fabric Filter Ash
Composite Days 1 to 4
Day 5 & 6 archived
Composite Days 1 to 6
Composite Days 1 to 6
Composite Days 1 to 4
Day 5 & 6 archived
Ash Properties
Ash Leaching
Same Tests as for Bottom Ash
Same Tests as for Bottom Ash
Ash Properties
Ash Leaching
Same as Fabric Filter Ash
Sequential Chemical Extraction (WTC)
Al, As, B, Cd, Co, Cr, Cu, Ni, Pb, Sb, Zn
Organics (RRL)
PCDD/PCDF CB/CP/PCB PAH
Sequential Chemical Extraction (WTC)
Al, As, B, Cd, Co, Cr, Cu, Ni, Pb, Sb, Zn
Reg 309 Leach Test (WTC)
Al, As, B, Cd, Co, Cr, Cu, Ni, Pb, Sb, Zn
Inorganics (WTC)
Al, As, B, Cd, Co, Cr, Cu, Ni, Pb, Sb, Zn
Reg 309 Leach Test (WTC)
Al, As, B, Cd, Co, Cr, Cu, Ni, Pb, Sb, Zn
. Total Solids
. Fixed Solids
. Acid Neut. Cap. (WTC)
Sequential Batch Leach Procedure (WTC)
Sequential Batch Leach Procedure (WTC)
For Organics Glass Containers
For Metals Plastic Containers
For Organics Glass Containers
For Metals Plastic Containers
Composite Cycles 1 to 5
Cycles 1 to 5 separately
Cycle 1 Filtered
Composite Cycles 2 to 5
Cycles 1 to 5 separately
Leachate Organics (RRL)
PCDD/PCDF CB/CP/PCB PAH
Leachate Metals (WTC)
Al, As, B, Cd, Co, Cr, Cu, Ni, Pb, Sb, Zn
Leachate Organics (RRL)
PCDD/PCDF CB/CP/PCB PAH
Same as Cycle 1 Filtered
Leachate Metals (WTC)
Al, As, B, Cd, Co, Cr, Cu, Ni, Pb, Sb, Zn

Figure 2. Outline of the Ash Characterization Program for the LVH-EFW Facility

for a period of at least one hour. A solution of 0.5 N HNO_3 was used instead of 0.3 N H_2SO_4 solution to provide more accurate ANC values on samples with low buffering capacities. All of the ash samples were dried and ground to pass a #100 mesh sieve prior to testing to hasten the chemical reactions. The test was performed in duplicate on all ash samples.

2.4 Sequential Batch Extraction Procedure

The Sequential Batch Extraction Procedure (SBEP), ASTM Method No. D4793-88, was conducted in duplicate on each of the four types of ash samples. It involved mixing each ash with distilled water at a 20:1 liquid- to-solid ratio for 18 hours. After mixing, the solid and liquid phases were separated via filtration through Whatman GF/C filters (for organic analyses) or through 0.45 micron pore size membrane filters (for metal analyses). The solids were then re-exposed to fresh distilled water at the same liquid-to-solid ratio and the procedure was repeated for 5 cycles. SBEP tests for inorganic contaminants were conducted in polyethylene bottles, whereas those for organic contaminants were conducted in "proofed" glass containers.

Inorganic analyses were conducted on leachates from each of the five cycles. After filtering, subsamples of the leachates were preserved with concentrated nitric acid to a pH of 2, and analyzed for the metals listed in Section 3.1. A separate 50 mL subsample of each leachate was submitted for chloride and sulphate analyses without prior preservation.

For each of the SBEP tests conducted on the bottom, boiler and economizer ashes, organic analyses were conducted on a composite sample of 200 mL aliquots of leachate from the five cycles. For the SBEP tests on the CT/FF ash, organic analyses were conducted on the leachate from cycle 1 and a composite sample of 250 mL aliquots of leachates from cycles 2 to 5. The leachates were stored at 4°C until analyzed.

2.5 Sequential Chemical Extraction Procedure

The ashes were subjected to the Sequential Chemical Extraction Procedure (SCE) to provide a basis for estimating the potential for metal leachability over a range of conditions generally encountered during the life of a landfill. The total concentration of a metal is separated into five distinct fractions using a step-wise extraction. Fraction

A is the ion exchangeable fraction which is considered to be available for leaching with water. Fraction B generally measures the surface oxide and carbonate bound metal ions which are considered readily available for leaching under acidic conditions. Metals removed in Fraction C are classified as iron and manganese bound ions and are considered to be available under severe reducing conditions such as those encountered in an older landfill site. Metals measured in Fraction D are bound to sulphides and organic matter. They are potentially available for leaching under oxidative conditions, but are not likely to be soluble under conditions generally found in a landfill. Fraction E contains the residual ions which are considered unavailable for leaching even under severe leaching conditions. A summary of the SCE is presented in Table 1. A detailed version of the procedure is given in Fraser and Lum (1983).

Table 1. Summary of the Sequential Chemical Extraction Procedure

Fraction	Digestion Method
A	1 M LiCl/CsCl in 60% CH_3OH
B	1 M CH_3COONa with Acetic Acid
C	1 M NH_4OH + HCl in 25% Acetic Acid
D	Nitric Acid with Peroxide, Heat + CH_3OOH_4 in 20% Nitric Acid
E	Aqua regia/HF with peroxide + HCl

2.6 Ontario Regulation 309 Leach Procedure

The Ontario Regulation 309 Leach Procedure (Reg 309) is used by the Ontario Ministry of the Environment to classify wastes as hazardous or non-hazardous (Government of Ontario, 1985). The test involved slowly mixing a 50 g sample of ash in 800 mL of distilled water for 24 hours at a pH of 5.0 plus or minus 0.2 (or less if the natural pH of the waste is acidic). A maximum of 2.0 milli-equivalents of acid per gram of waste can be added to the sample during the test to lower the pH to the required level.

3.0 RESULTS AND DISCUSSION

3.1 Total Solids and Fixed Solids Content

The average total solids and fixed solids contents of the ashes are given in Table 2. The total solids of the bottom ash over the five day test period averaged 41.5%. The average total solids content of the boiler, economizer and CT/FF ashes were 99.8%, 94.5% and 98.2%, respectively. The low total solids content in the bottom ash was due to the fact that this ash stream was collected from the ash storage bins after quenching. Since the fly ashes were dry when they were sampled, the 5.5% moisture in the economizer ash may indicate that the ash is hygroscopic.

Table 2. Average Total Solids and Fixed Solids Content

Ash Type	Total Solids (%)	Fixed Solids (% of dry weight)
Bottom Ash	41.5	70.8
Boiler Ash	99.8	99.9
Economizer Ash	94.5	97.8
CT/FF Ash	98.2	94.1

The boiler and economizer ashes contained very little volatile or combustible material, averaging 99.9% and 97.8% fixed solids, respectively. The CT/FF ash contained slightly more volatile or combustible material than the other fly ashes, having a fixed solids content of 94.1%.

The average fixed solids in the dried bottom ash samples was about 70%. About 20% volatiles or combustibles in the bottom ash is typical of this type of system and is due to the semi-pyrolytic conditions of the primary chamber (Environment Canada, 1985). The 30% combustibles from this facility may indicate "poor" operating conditions, hence, relatively "poor" burnout of the refuse. Measures have been taken by LVH-EFW to optimize the operating conditions and thereby reduce the combustible fraction in the bottom ash (Victoria Hospital Corporation, 1989).

In comparison, mass burn systems obtain a much more complete burnout of refuse, with fixed solids contents of bottom ash being typically greater than 95%, i.e., less than 5% volatile or combustible content (Environment Canada, 1988). Conversely, fly ash from mass burn systems contain a higher volatile or combustible fraction than does fly ash from two-stage or modular combustion systems. This is due to less turbulence in the primary chamber (resulting in less carry-over of particulates) and the highly oxidative conditions of the secondary combustor in two-stage systems.

3.2 Acid Neutralization Capacity

The average acid neutralization capacities (ANC) of the ashes are given in Table 3. The ANC of the bottom ash was slightly greater than 3.0 milliequivalents of acid per gram of waste (meq/g). The ANC's of the fly ashes ranged from almost 1.0 to 5.5 meq/g.

These results indicate that very substantial quantities of acidic precipitation, at an assumed pH of 4.4, would be required to reduce the pH of one gram of the bottom ash, economizer ash and CT/FF ash to a pH of 4.4. Approximately 75 litres would be required for the bottom ash, 62 litres for the economizer ash and almost 135 litres for the CT/FF ash. The boiler ash, which had an initial pH of 5.65, contained little in the way of buffering capacity (below 1.0 meq/g). This indicates that the boiler ash contains some form of acidic material which may have either condensed or sorbed onto the particles from the flue gas stream.

Table 3. Average Acid Neutralization Capacity Results

Ash Type	Initial pH	ANC (meq/g)
Bottom Ash	10.20	3.05
Boiler Ash	5.65	0.95
Economizer Ash	7.35	2.48
CT/FF Ash	11.35	5.52

It is important to note that this standard test does not provide sufficient data to calculate ANC values in the range of pH levels where metal solubility increases dramatically (mildly acidic to neutral). For example, the initial pH of the economizer ash was already in the neutral pH range and would probably only require initial contact with precipitation for metal solubilization to occur (see Section 3.4). Conversely, an equal quantity of the lime-amended CT/FF ashes would have to be contacted with a substantial volume of precipitation to reduce the pH to the neutral range. These results and those obtained in the previous study (Sawell et al., 1989) suggest that a modified ANC test should be performed in future studies to permit data interpretation in terms of potential metal mobility.

3.3 Chemical Composition

3.3.1 Organic Contaminants

Results from the organic analyses of the ashes are given in Table 4. The results have been corrected for recovery of analytical standards. Detailed results are given in Appendix 2.

Table 4. Organic Analytical Results (ng/g or ppb)

Compound	Bottom Ash	Boiler Ash	Economizer Ash	CT/FF Ash
PCDD	ND	79.7	273	60.1
PCDF	ND	34.1	87.7	53.0
PCB	ND	27.3	47.0	ND
PAH	2190	14.0	188	65.0
CP	34.1	20.1	164	864
CB	6.7	613	829	220

ND = not detected.
Detection limits - PCDD and PCDF: 0.04 to 0.3 ng/g
- PCB, PAH, CP and CB: 4 to 40 ng/g

The concentrations of organic compounds in the bottom ash, with the exception of PAH at 2190 ng/g (ppb), was less than 34.1 ng/g. The highest measured organic concentrations in the fly ashes were CB in the boiler and economizer ashes (613 and 829 ng/g, respectively) and CP in the CT/FF ash (864 ng/g). Concentrations of PCDD, PCDF, PAH, PCB and CP in the boiler and economizer ashes were much lower, ranging from 14.0 to 273 ng/g. In the CT/FF ash, PCDD, PCDF and PAH concentrations ranged from 53 to 65 ng/g, the CB concentration was 220 ng/g, and PCB was not detected. The levels of all these compounds are within the range of those measured in ashes during the NITEP study at the P.E.I. energy-from-waste (two-stage combustion) facility (Environment Canada, 1985).

Concentrations of most organic compounds, with the exception of PAH, were higher in the fly ashes than in the bottom ash. This general trend is consistent with that observed in previous studies (Environment Canada, 1985 and 1988; EPA, 1987). However, the distribution of these organic compounds within the three types of fly ash, is not consistent with previous results from the NITEP study on the air pollution control pilot plant system (Environment Canada, 1988). The highest concentrations of organic compounds in the fly ashes from the previous study were found in fabric filter ash which has the finest sized particles. The highest organic concentrations in the fly ashes from the LVH facility, with the exception of CP, were found in the economizer ash which typically consists of larger sized particles than CT/FF ash. The difference may be due to the relatively high lime addition rates utilized at the LVH facility which diluted the concentrations of organic compounds in the CT/FF ash.

3.3.2 Inorganic Contaminants

The total concentrations of the metals in the four ash types are given in Table 5. In general, these concentrations are within the ranges of those recorded during the NITEP study conducted at the P.E.I. facility (Bridle and Sawell, 1985). The bottom ash contained low to moderate concentrations of most of the measured metals (less than 2000 ppm), with the exception of a relatively high concentration of zinc (about 0.6%) and a very high concentration of aluminum (over 4.0%). The boiler, economizer and CT/FF fly ashes contained low to moderate concentrations of antimony, arsenic,

boron, cadmium, chromium, cobalt, copper and nickel, and very high concentrations of aluminum, lead and zinc.

Table 5. Total Metal Concentrations in the Ashes (ug/g or ppm)

Element	Bottom Ash	Boiler Ash	Economizer Ash	CT/FF Ash
Aluminum	40400	30100	33500	17200
Antimony	71.8	494	627	1090
Arsenic	2.9	126	87.5	97
Boron	149	116	162	150
Cadmium	<5.0	788	763	821
Cobalt	288	44.8	32.5	13.5
Chromium	430	385	286	187
Copper	1130	675	603	627
Nickel	506	156	179	46.7
Lead	1970	23800	24000	13400
Zinc	6280	40300	35000	38500

The distribution or partitioning of these metals between the bottom ash and the fly ashes is consistent with trends noted in many other studies on residuals from incineration processes (e.g., Klien et al., 1975; Brunner and Monch, 1986; Schneider, 1986; Sawell et al., 1986; EPA, 1987; Vogg, 1987). Typically, less volatile metals such as chromium, cobalt and nickel are measured in higher concentrations in bottom ashes than in fly ashes. Conversely, more volatile metals such as arsenic, cadmium, lead and zinc tend to be concentrated in the fly ashes.

In comparing the concentrations of some of the more volatile metals (i.e., arsenic, lead and zinc) in the three types of fly ashes, it was expected that the highest concentrations of these metals would be measured in the CT/FF ash, rather than either the boiler or economizer ashes. This difference is probably due to the dilution effect caused by the lime in the CT/FF ash.

3.4 Leachability

3.4.1 Organic Contaminant Leachability

The average results of the organic analyses conducted on the leachates from the Sequential Batch Extraction Procedure (SBEP) are presented in Table 6. The results for the bottom, boiler and economizer ashes are for composite samples of leachates from the five test cycles. The results for the CT/FF ash are for leachate from cycle 1 and for a composite sample of leachates from cycles 2 to 5.

None of the organic compounds in the bottom ash were mobile in water. No chlorophenol was detected in any of the fly ash leachates. Trace levels of PCDD and PCDF were detected in the boiler ash leachates. Trace levels of PCB were detected in the economizer and CT/FF (composite of cycles 2-5) leachates. PAH was also detected in the CT/FF ash leachate from cycles 2-5. CB was detected in all of the fly ash leachates.

Table 6. Organic Contaminant Concentrations in the Leachates (ug/L or ppb)

Parameter	Bottom Ash	Boiler Ash	Economizer Ash	CT/FF Ash	
				Cycle 1	Cycles 2-5
PCDD	ND	0.008	ND	ND	ND
Furans	ND	0.006	ND	ND	ND
PCB's	ND	ND	0.06	ND	0.02
PAH's	ND	ND	ND	ND	0.02
CP	ND	ND	ND	ND	ND
CB	ND	2.28	0.08	0.06	0.02

ND = not detected.
Detection limits - PCDD and PCDF: 0.0003 to 0.001 ug/L
- PCB, PAH, CP and CB: 0.01 to 0.02 ug/L.

Since most of these organic compounds are considered insoluble in water, these results suggest that the compounds detected in the leachates were probably strongly sorbed onto sub-micron sized particles which remained suspended in the leachate after filtration. This has also been noted in other studies (EPA, 1987; Sawell and Constable,

1988). In light of this, consideration of the potential for contaminant transport in sub-surface groundwaters via ultra-fine particulate migration should be considered when choosing a disposal site.

3.4.2 Inorganic Contaminant Leachability

The ashes were also subjected to the SBEP to determine variations in leachate pH and potential inorganic contaminant mobility in water over a wide range of liquid-to-solid ratios (20:1 to 100:1). It is important to note that the results are not indicative of leachate quality from a monofill, but only represent potential fractions available for leaching in water. The detailed results of the inorganic analyses conducted on leachates from the SBEP are given in Appendix 2.

Variations in the average pH of the leachates from the four types of ash are shown in Figure 3. The average pH of the bottom ash leachates was highly alkaline, and increased slightly from 10.4 to 10.8 over the five cycles. As expected, the pH of the lime-amended CT/FF ash leachates was also highly alkaline, and decreased slightly from 11.5 to 11.2 over the five cycles. The boiler ash produced leachates which were mildly acidic to neutral, while the pH of the economizer ash leachates increased from neutral to mildly alkaline during the five cycles of the test.

The pH results for the bottom, boiler and economizer ash leachates are consistent with those recorded during the NITEP study on the modular (two-stage) combustion system at P.E.I. (Bridle and Sawell, 1986). It appears that the mildly acidic and neutral pH of the boiler and economizer ashes is characteristic of two-stage combustion systems and may be related to the high degree of "fouling" which occurs in the heat recovery units of modular combustion systems. These "fouling" deposits are formed by complex chemical and physical processes which are currently not fully understood (Glen et al., 1988). Further study of these formation mechanisms is recommended.

The average cumulative total dissolved solids (TDS) of the leachates are given in Figure 4. The fly ashes were the most soluble in that almost 54% of the boiler ash, 39% of the economizer ash and 65% of the CT/FF ash were solubilised during the test, compared to only 3.6% of the bottom ash. Most of the dissolution of all the ashes occurred during the first cycle of the test.

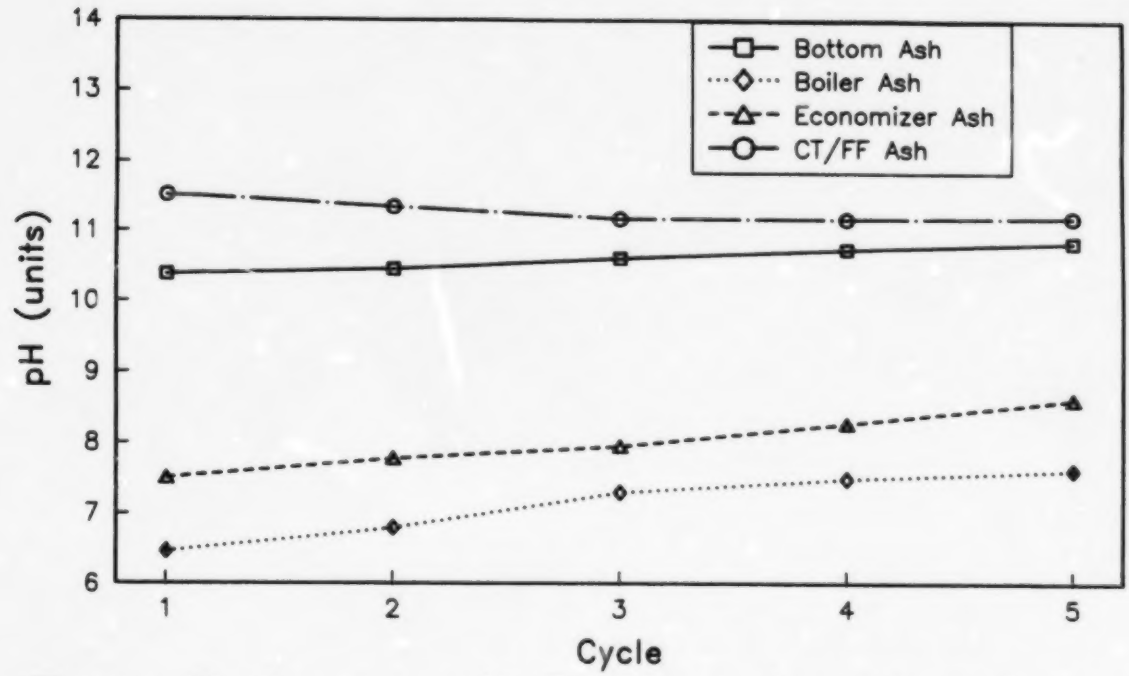

Figure 3. Average pH Readings from the Sequential Batch Extraction Procedure

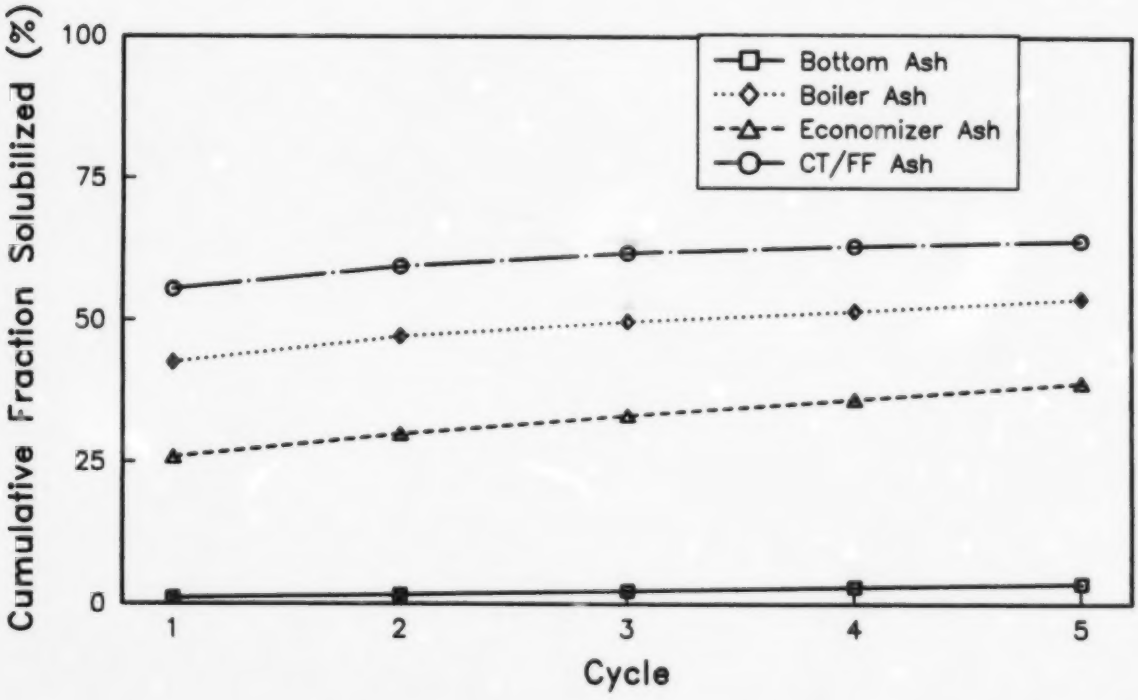

Figure 4: Average Cumulative Fraction Solubilized Results from the Sequential Batch Extraction Procedure

The average cumulative sulphate release results are presented in Figure 5. Release is defined as the ratio of the mass of contaminant measured in the leachates to the original mass of the leached sample. Sulphate release was greatest from the boiler ash, followed by the economizer ash, CT/FF ash and bottom ash. The rate of sulphate release from the 3 fly ashes was approximately the same after the first cycle. Sulphate release from the bottom ash occurred mainly during the first cycle.

Assuming that the sulphate released from the ashes during the 5 cycles is proportional to the total sulphate concentration in each ash, the boiler ash contained almost twice as much sulphate as the economizer ash, which in turn contained almost 1.5 times more than the CT/FF ash. The bottom ash only contained about 2% of the sulphate in the boiler ash. This trend is consistent with results from previous NITEP studies and is due to the fact that most sulphates are not volatile at the temperatures inherent in municipal waste incinerators (Sawell and Constable, 1988). As a result they are carried over from the incineration chamber(s) in particulate form and trapped out in the heat recovery units and the air pollution control systems. The economizer and CT/FF ashes contained proportionately less sulphate than the boiler ash due to the dilution effects of other compounds which condensed out of the flue gas stream onto the entrained particulates after leaving the boiler, and of lime addition in the CT/FF unit.

The average cumulative chloride release results from the ashes during the SBEP are given in Figure 6. Almost all of the chloride dissolution took place during the first cycle. Since the solubility of chloride in water is generally independent of pH, it is assumed that 100% of the chloride in each ash had solubilised by the end of the test, and that the total amount of chloride released during the five cycles is equal to the total chloride concentration in an ash. The chloride content of the ashes increased from bottom ash through to CT/FF ash. The bottom ash contained a slightly lower concentration of chloride than the boiler ash (i.e., 0.52% versus 0.65% respectively). The economizer and CT/FF ashes contained about 6.2% and 28% chloride, respectively. The large proportion of chloride in the CT/FF ash is partly the result of the condensation of HCl from the flue gas stream in the conditioning tower and the sorption onto particles after lime injection prior to the fabric filter unit.

The average cumulative fractions leached of each of the metals detected in the leachates from the SBEP are given in Figure 7 for the bottom ash, Figure 8 for the

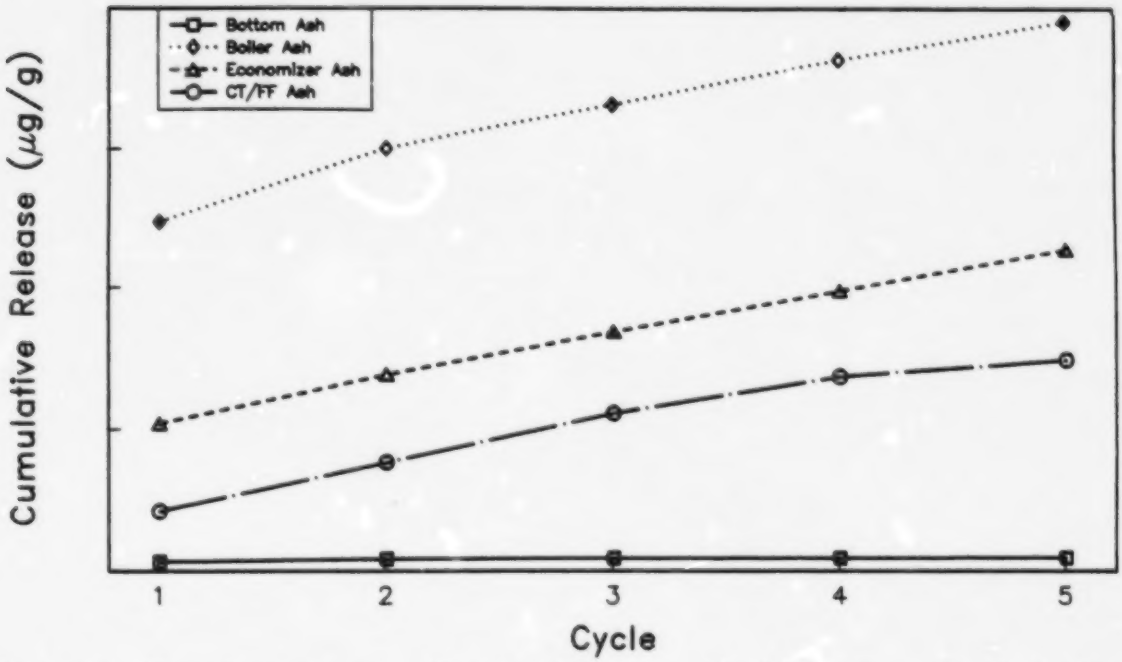

Figure 5: Average Cumulative Release of Sulphate During the Sequential Batch Extraction Procedure

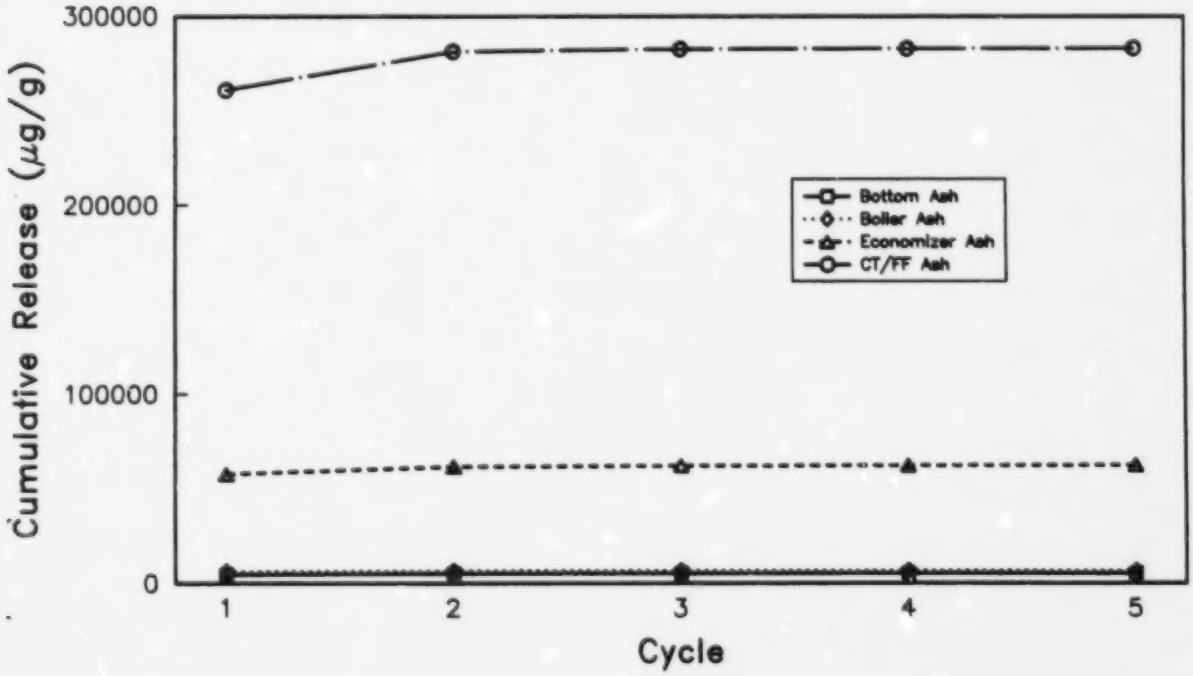

Figure 6: Average Cumulative Release of Chloride During the Sequential Batch Extraction Procedure

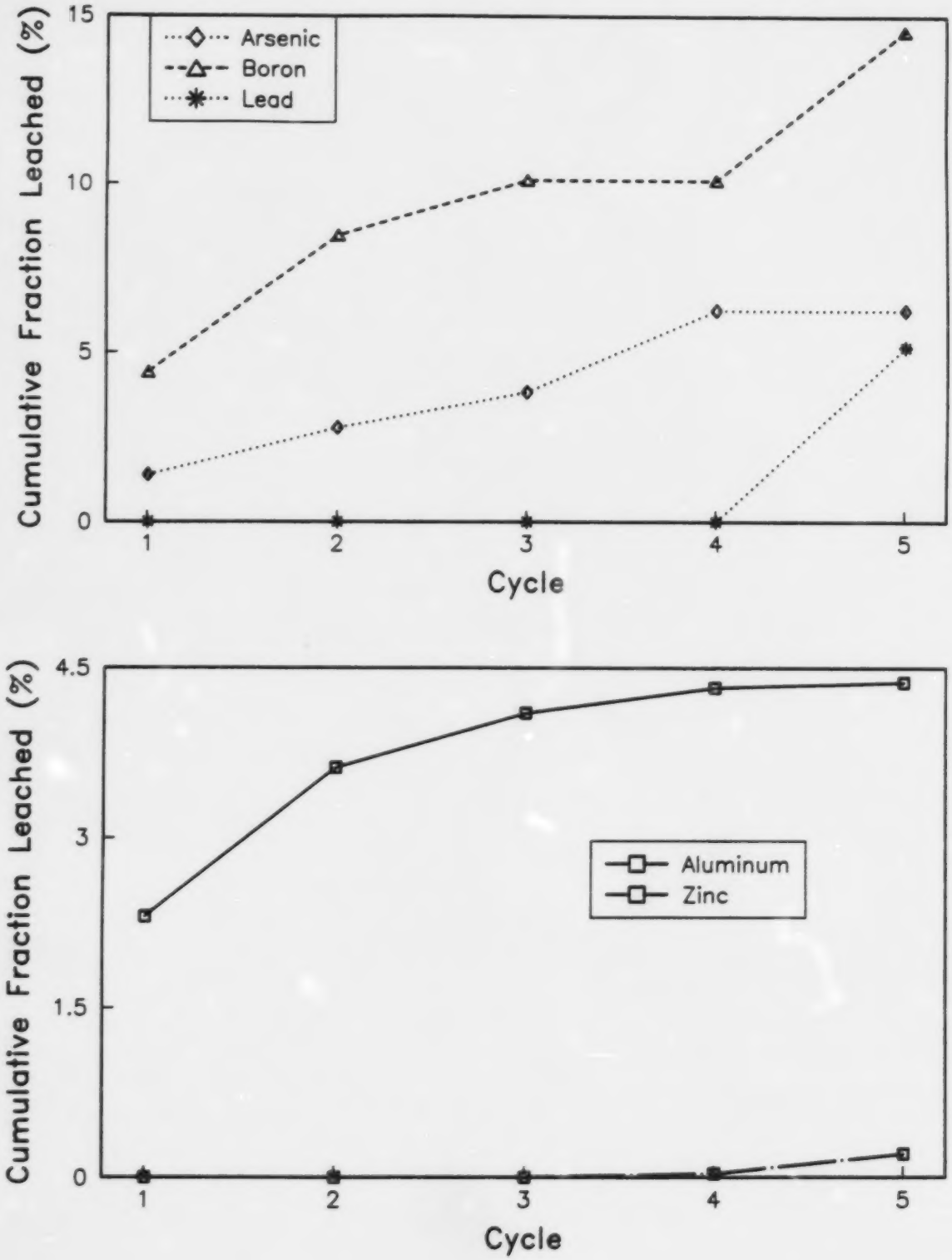

Figure 7: Cumulative Fraction Leached from Bottom Ash During the Sequential Batch Extraction Procedure

boiler ash, Figure 9 for the economizer ash and Figure 10 for the CT/FF ash. Fraction leached is defined as the ratio of the mass of a contaminant in the leachate to the mass of that contaminant in the original sample, expressed as a percentage.

Bottom Ash

Antimony, cadmium, cobalt, chromium, copper and nickel were not detected in any of the bottom ash leachates. The average cumulative fractions leached of aluminum, boron, arsenic and lead ranged between 4.4% and almost 15%. A very small proportion (about 0.2%) of the zinc present in the ash was detected in the leachates. Aluminum, arsenic and boron leaching occurred throughout the 5 cycles, whereas lead and zinc only commenced leaching at the third and fourth cycles.

Boiler Ash

Antimony and chromium were not detected in any of the boiler ash leachates. About 0.1% of the aluminum and arsenic and 0.6% of the lead in the boiler ash were leached during the test. About 2% of the copper, 4% of the cobalt, 6% of the nickel, 25% of the boron, 45% of the zinc and all of the cadmium in the ash were leached over the five cycles. Almost all leaching occurred during the first cycle, with the exception of lead which continued to leach throughout the five cycles.

Economizer Ash

Antimony, cobalt, chromium and copper were not detected in any of the economizer ash leachates. Less than 0.1% of the aluminum and arsenic and 0.4% of the lead present in the economizer ash were solubilised. About 1% of the nickel, 4.5% of the zinc, 24% of the boron and 46% of the cadmium in the ash were leached over the five cycles. Almost all leaching occurred during the first cycle.

Conditioning Tower/Fabric Filter Ash

Antimony, cadmium, cobalt, chromium, copper and nickel were not detected in any of the CT/FF ash leachates. Less than 0.3% of the zinc and arsenic, about 0.6% of the aluminum, over 36% of the boron and almost 40% of the lead in the CT/FF ash were leached during the test. Almost all zinc and lead leaching occurred during the first cycle. Arsenic and boron leached at a fairly constant rate after cycle 1. The aluminum leaching rate was constant over the first 4 cycles, then increased in cycle 5.

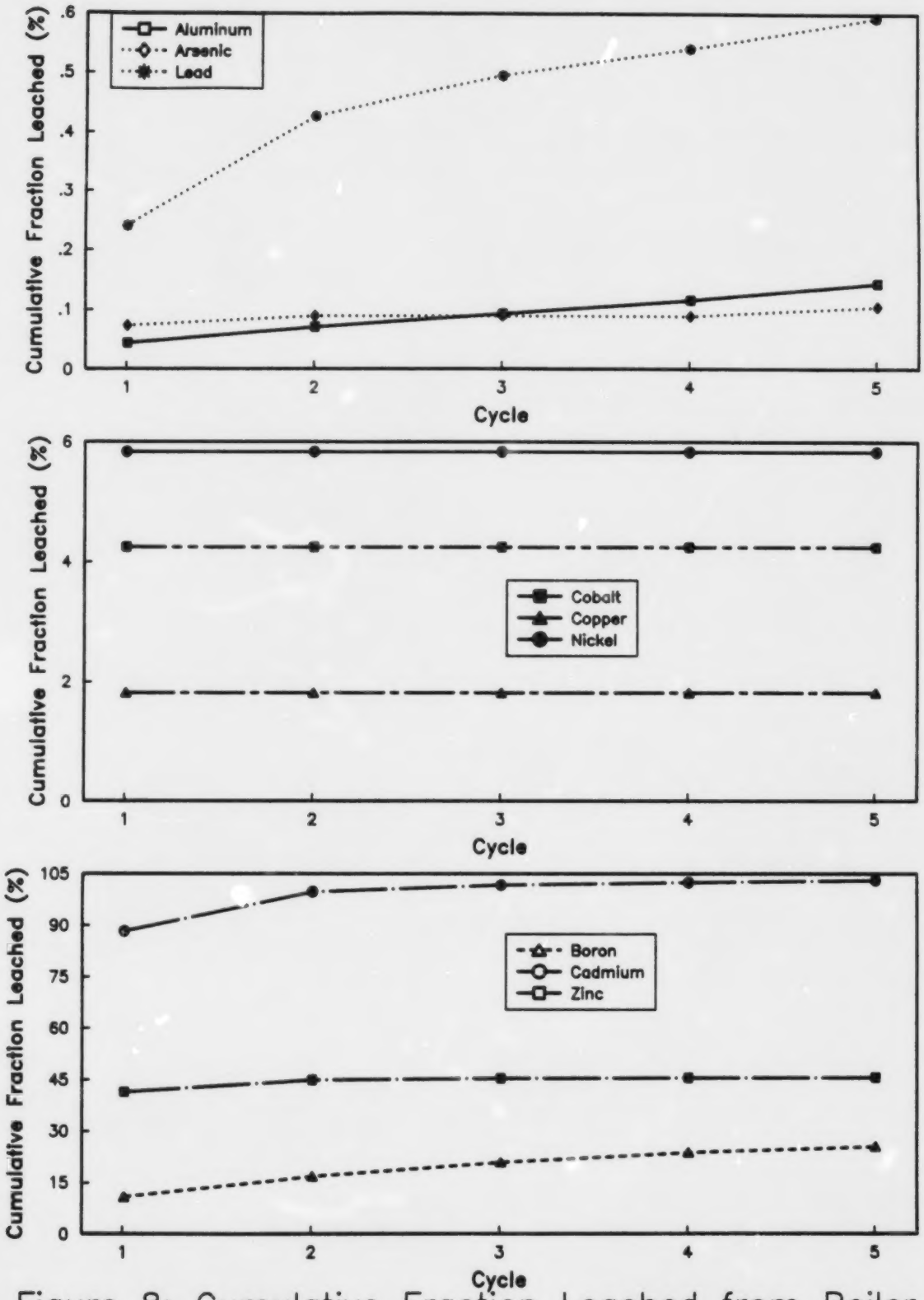

Figure 8: Cumulative Fraction Leached from Boiler Ash During the Sequential Batch Extraction Procedure

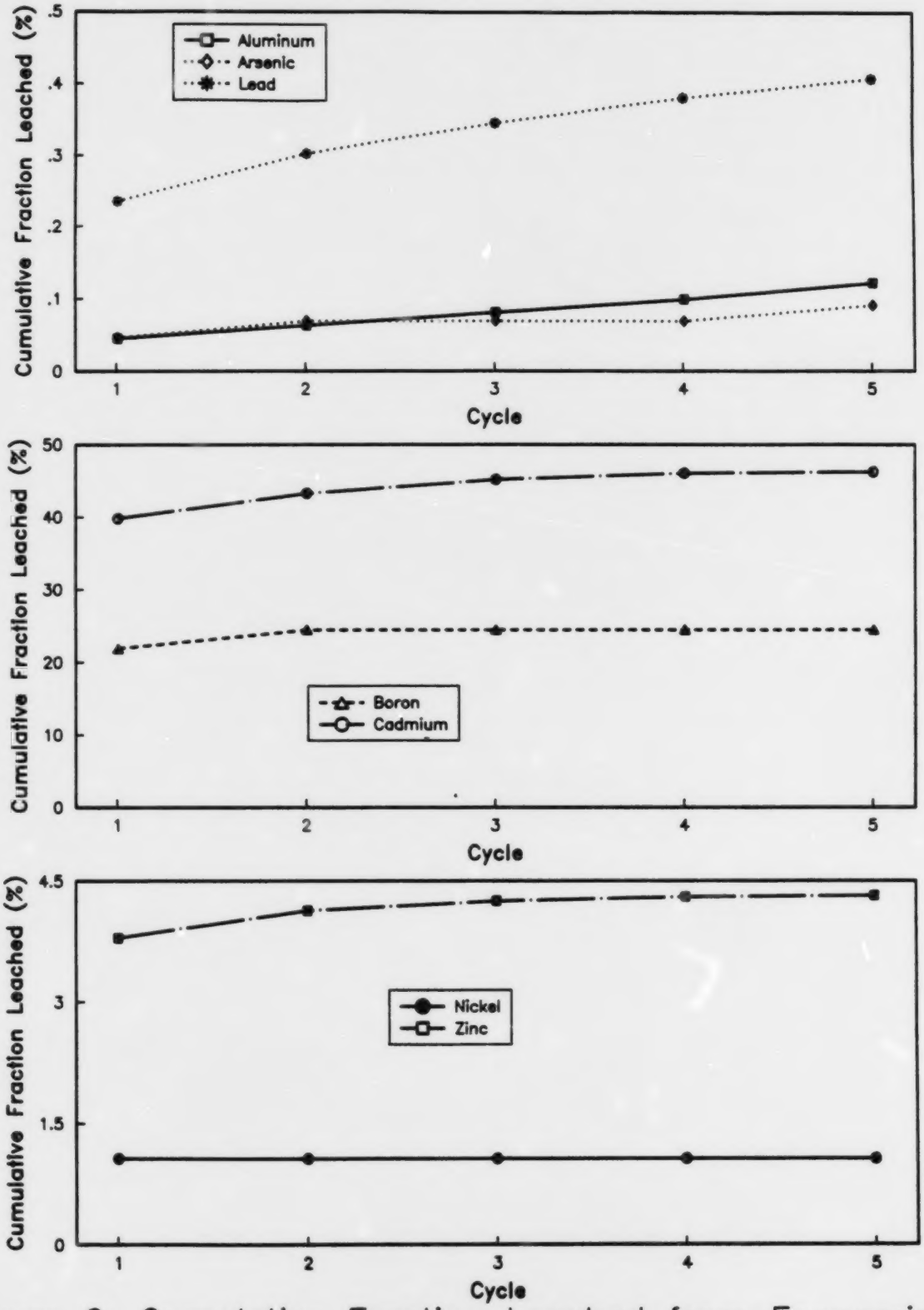

Figure 9: Cumulative Fraction Leached from Economizer Ash During the Sequential Batch Leach Procedure

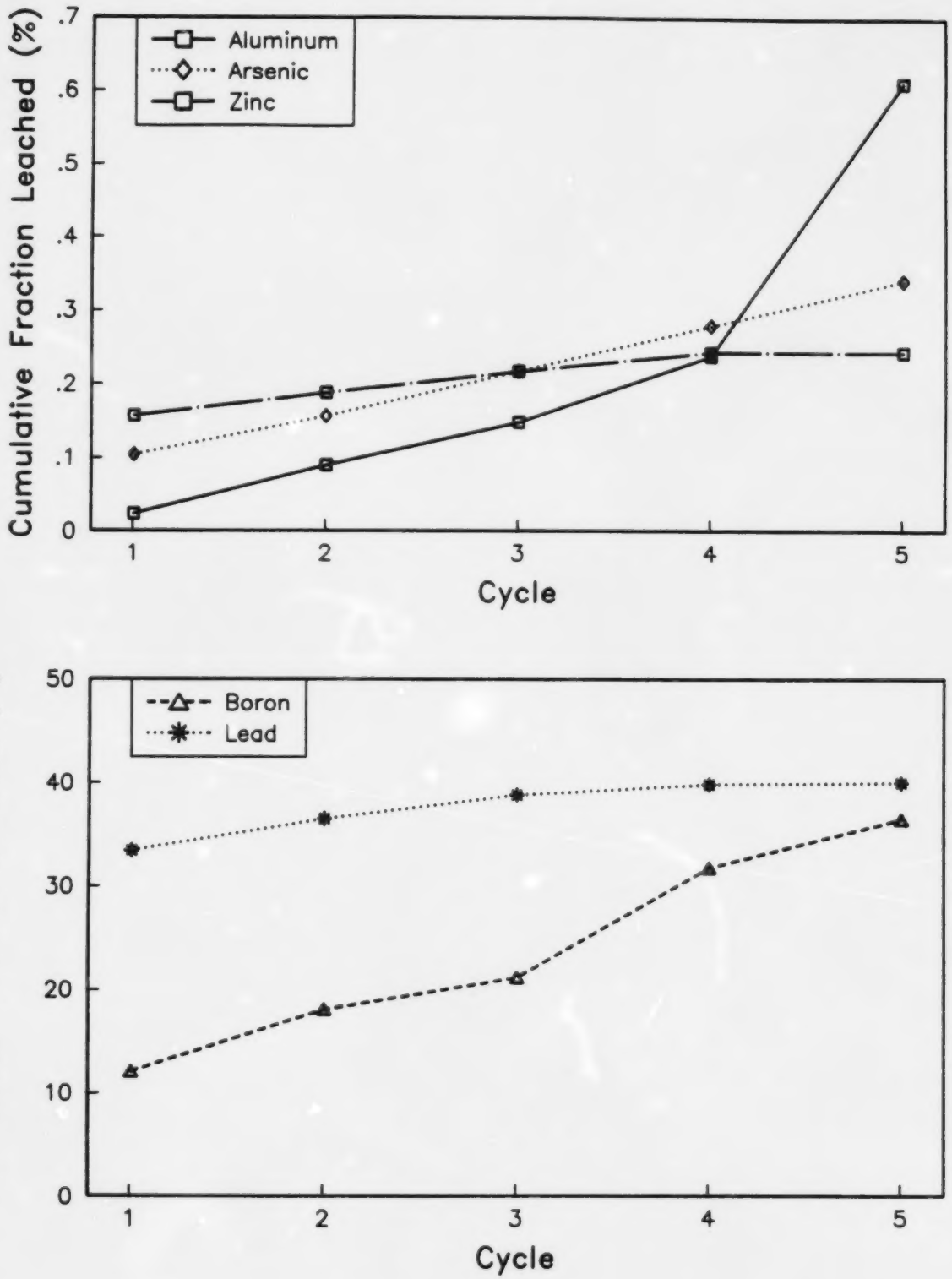

Figure 10: Cumulative Fraction Leached from CT/FF Ash During the Sequential Batch Extraction Procedure

pH Effect

Results from the previous NITEP studies have shown that pH is one of the major factors controlling metal solubility. Metals such as cadmium and zinc are highly soluble in acidic to neutral pH conditions. The SBEP results are consistent with this fact as shown in Figure 11 where the fraction leached of cadmium and zinc in all 4 ash types is plotted against the corresponding pH from the first cycle of the SBEP. A metal such as lead typically exhibits amphoteric properties, i.e., is more soluble under acidic and highly alkaline pH levels than under neutral to mildly alkaline conditions. The fractions of lead leached from each of the 4 ash types during each of the 5 cycles of the SBEP are plotted against leachate pH in Figure 12. The results show that lead was less soluble in the neutral leachates from the boiler and economizer ashes than in the highly alkaline leachates from the bottom and CT/FF ashes.

3.4.2 Sequential Chemical Extraction

The Sequential Chemical Extraction (SCE) procedure was used to estimate the potential leachability of the metals in the ashes, under a range of conditions generally associated with landfills. The SCE is a step-wise separation of the total concentration of each metal into five distinct fractions using increasingly more aggressive leaching media to digest the solid material. Fraction A is considered the fraction available for leaching upon contact with water. Fraction B is considered available for leaching under the acidic conditions encountered in an established landfill site. Fraction C is considered available for leaching under the severe reducing conditions of an older landfill site. Fractions D and E are considered unavailable for leaching under most environmental leaching conditions. A summary of these interpretations is given in Table 7. The potential fraction of a metal available for leaching in a landfill is assumed to be represented by the sum of Fractions A + B; Fraction C could be added if very severe cleaning conditions were to prevail. It must be noted that the results from this test are not indicative of field leachate concentrations under the conditions suggested and that the interpretations are assumed generalities.

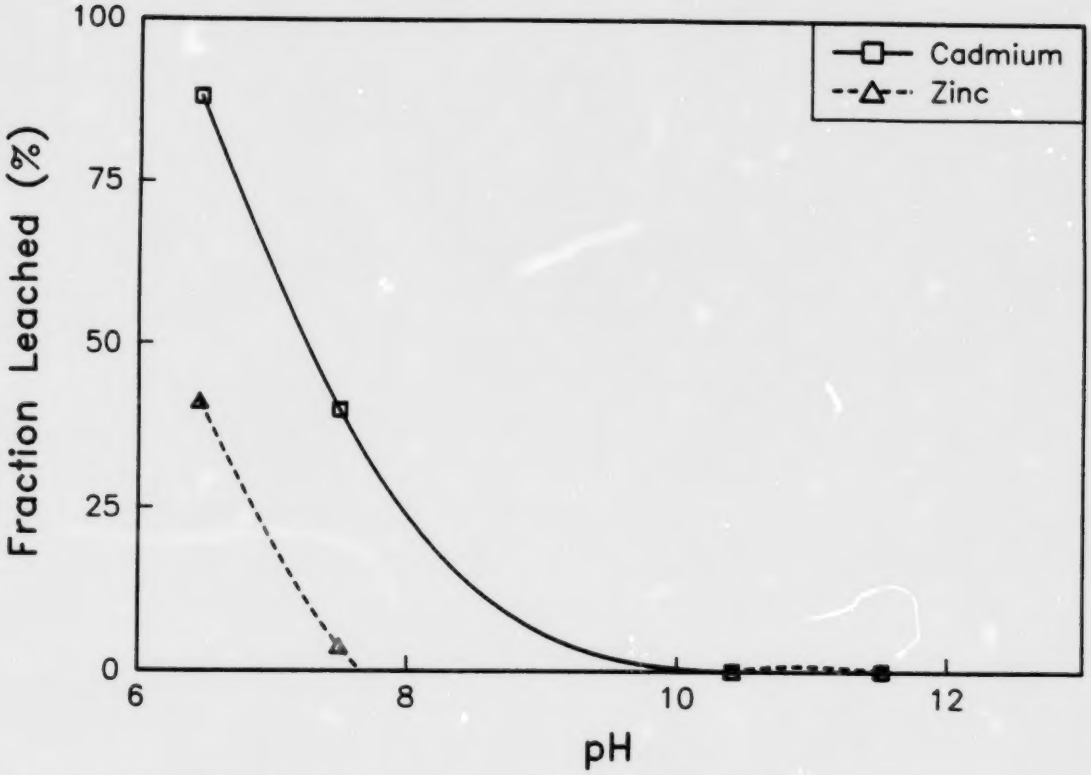

Figure 11. Effect of pH on the Solubility of Cadmium and Zinc

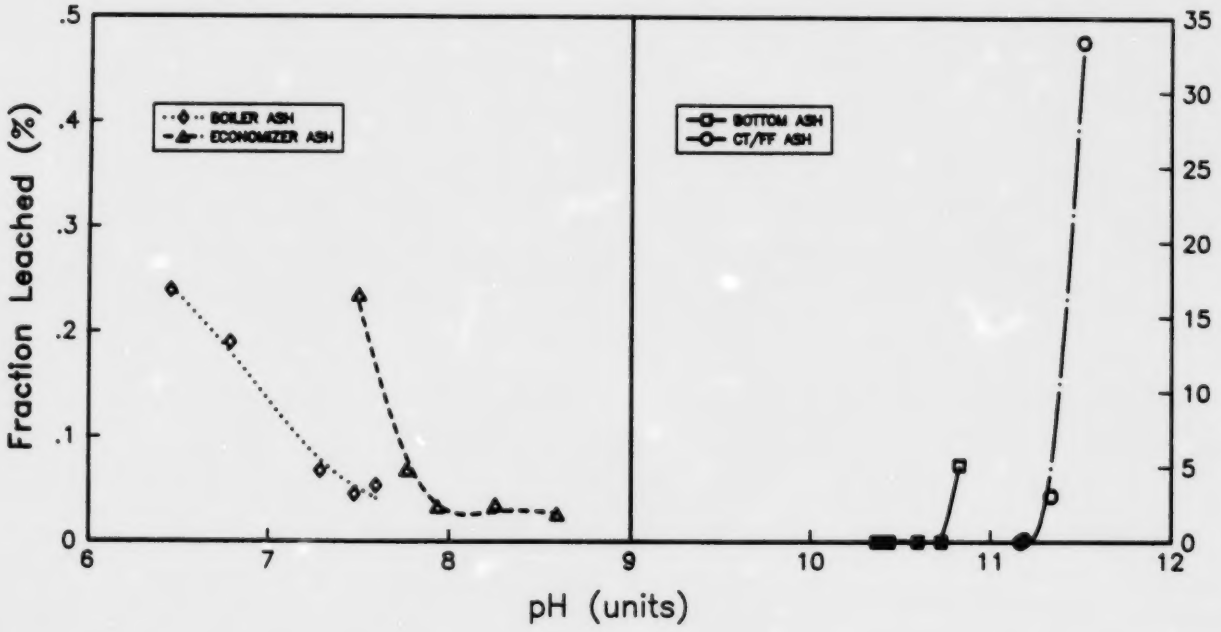

Figure 12: Effect of pH on the Solubility of Lead

Table 7. Summary of the Sequential Chemical Extraction Procedure Description and Interpretations

Fraction	Description	Interpretation
A	Ion exchangeable	Immediately available for leaching
B	Surface oxide and carbonate bound ions	Potentially available for leaching under acidic conditions
C	Iron and manganese bound metal ions	Potentially available for leaching under reducing conditions
D	Sulphide and organic matter bound ions	Unavailable for leaching under normal leaching conditions
E	Residual metal ions	Unavailable for leaching

The results of the SCE analyses are given in Figure 13 along with the total concentrations of metals. Due to analytical difficulties, arsenic and boron were not measured in this procedure.

Bottom Ash

About 3% of the chromium, 12-13% of the copper and nickel, 18% of the aluminum, and over 51% of the cobalt, lead and zinc present in the bottom ash are potentially available for leaching under acidic leaching conditions (Fractions A and B) which may prevail in a landfill.

Boiler Ash

None of the antimony, about 3% of the chromium and about 10% of the nickel present in the boiler ash are potentially available under conditions defined in Fractions A + B. Almost 4% of the aluminum, over 33% of the cadmium, and over 44% of the cobalt, copper, lead and zinc are potentially available for leaching under acidic leaching conditions.

Economizer Ash

Less than 8% of the antimony and chromium, and less than 13% of the aluminum and nickel present in the economizer ash are potentially available for leaching under acidic conditions. About 33% of the cobalt and large proportions (from 48% to 92%) of

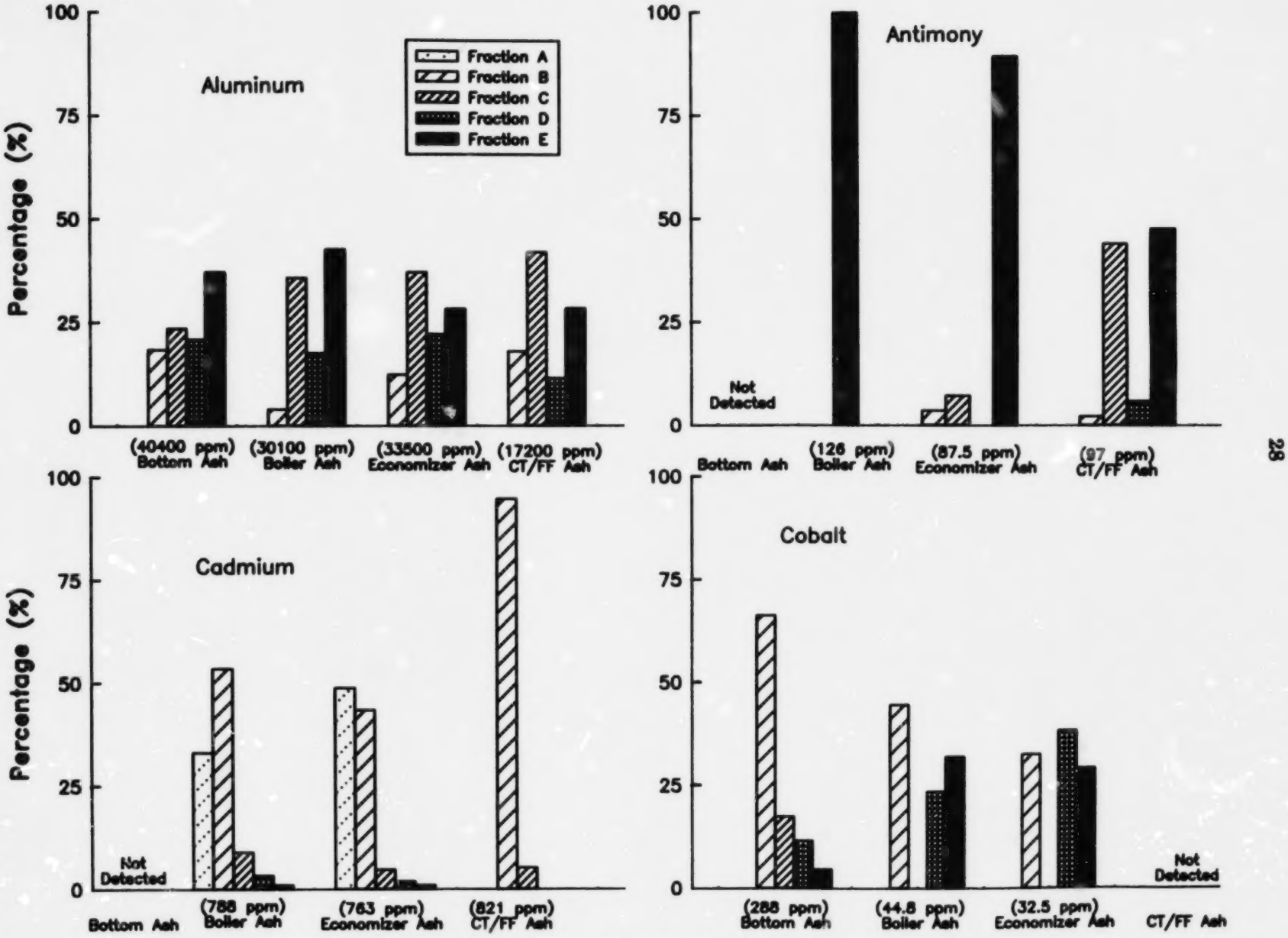

Figure 13a: Sequential Chemical Extraction Results

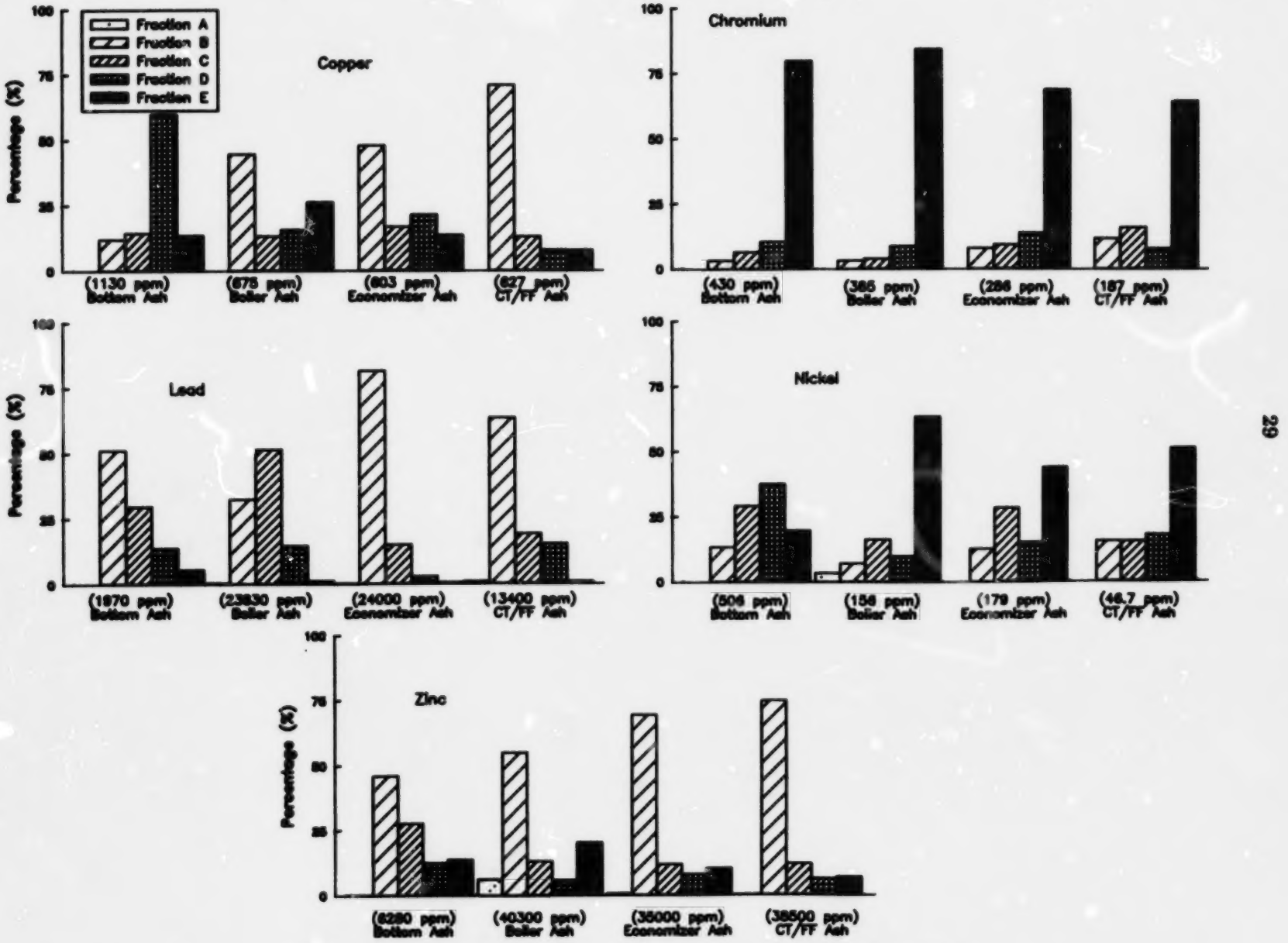

Figure 13b: Sequential Chemical Extraction Results

the cadmium, copper, lead and zinc are potentially available for leaching.

Conditioning Tower/Fabric Filter Ash

Most (65 to 95%) of the cadmium, copper, lead and zinc, and about 2 to 18% of the antimony, chromium and nickel in the CT/FF ash, are potentially available for leaching.

In general, with the exceptions of aluminum, cobalt and nickel, a larger proportion of the metals in the fly ashes, than in the bottom ash, are potentially available for leaching under the range of conditions which may be encountered in a landfill site. This is consistent with results from previous studies (e.g., Sawell et al., 1987; Wadge and Hutton, 1987).

3.4.3 Ontario Regulation 309 Leach Test

Average leachate concentrations from the Regulation 309 leach test (Reg 309) performed at WTC are given in Table 8 and are compared to the regulatory limits given in Schedule 4 of Reg 309. Potentially, leachates with contaminant concentrations which exceed these regulatory limits would be considered hazardous. At the present time, however, MSW incinerator ashes are exempt from Reg 309.

All of the ashes produced leachates which exceeded regulatory limits for one or more metals. For the bottom ash, lead concentrations in the leachate were slightly higher than the regulatory limit. This is consistent with the slightly higher concentration measured in the bottom ash (Table 5) in comparison to those observed in bottom ashes from other facilities (Environment Canada, 1985; Sawell and Constable, 1988). The lead concentrations in the economizer and CT/FF ash leachates were 4 times higher than the regulatory limit. Cadmium concentrations in the boiler, economizer and CT/FF ash leachates exceeded the Schedule 4 limits by at least a factor of 54. If these ashes were subject to Reg 309, all of these ashes would be considered hazardous wastes.

Further testing of the individual daily composite samples of all the ashes was conducted by the Ontario Ministry of the Environment and the results are available in Appendix 3. In addition, further tests were conducted by LVH on ashes collected under more "efficient" incinerator operating conditions (see Section 3.1). It was anticipated that these "efficient" operating conditions would improve the quality of the bottom ash

by volatilizing a larger portion of lead from the refuse. Preliminary indications are that this did occur and that the bottom ash would now meet the Reg 309 criteria for a non-hazardous material (Victoria Hospital Corporation, 1989).

Table 8. Average Ontario Regulation 309 Leach Test Results (ppm)

Element	Bottom Ash	Boiler Ash	Economizer Ash	CT/FF Ash	Regulatory Limits
Aluminum	1.29	3.04	0.09	0.91	-
Antimony	<0.50	<0.50	34.6	<0.50	-
Arsenic	0.01	0.03	0.006	0.003	5.0
Boron	2.11	1.6	3.65	4.15	500
Cadmium	0.14	43.2*	27.3*	35.4*	0.5
Cobalt	0.20	0.27	0.20	0.15	-
Chromium	0.18	<0.05	0.09	<0.05	5.0
Copper	0.87	16.1	7.43	3.27	-
Lead	6.83*	4.15	19.3*	21.6*	5.0
Nickel	0.59	0.87	0.57	0.09	-
Zinc	54.7	1340	1090	1060	-

"*"Indicates concentration exceeds limits

4.0 SUMMARY AND CONCLUSIONS

Concentrations of the organic compounds measured in the LVH ashes were consistent with those recorded in other studies (e.g., Sawell et al., 1987; EPA, 1987). Organic concentrations in the bottom ash were less than 34 ng/g (ppb), with the exception of PAH at 2190 ng/g (ppb). None of the organics in the bottom ash were mobile in water.

Organic concentrations were higher in the fly ashes than in the bottom ash, with the exception of PAH. The highest measured organic concentrations in the fly ash were CB in the boiler and economizer ashes (613 and 829 ng/g, respectively) and CP in the CT/FF ash (864 ng/g). Concentrations of PCDD, PCDF, PAH, PCB and CP in the boiler and economizer ashes were much lower than CB, ranging from 14 to 273 ng/g. In the CT/FF ash, PCDD, PCDF and PAH concentrations ranged from 53 to 65 ng/g, the CB concentration was 220 ng/g, and PCB was not detected. Trace levels of some of the organic contaminants were detected in the fly ash leachates. Most of these organic contaminants are considered to be immobile in water and their presence in the filtered leachates was probably due to their sorption onto ultra-fine suspended particulates.

The bottom and fly ashes contained low to moderate concentrations (below detection to 1100 ppm) of antimony, arsenic, boron, cadmium, cobalt, chromium, copper and nickel. They also contained high concentrations of aluminum (1.7 to 4.0%), lead (0.2 to 2.4%) and zinc (0.6 to 4.0%).

Results from the Sequential Batch Extraction Procedure (SBEP) indicate that the bottom ash is much less soluble in water (3.6% solubilised over the 5 cycles) than any of the three fly ashes (average of about 53% solubilised). Metals such as cadmium and zinc were more soluble in the neutral leachates from the boiler and economizer ashes, whereas amphoteric metals such as aluminum and lead were more soluble in the highly alkaline leachates from the bottom and CT/FF ashes. Large fractions of the cadmium in the boiler and economizer ashes, the lead in the CT/FF ash and the zinc in the boiler ash were leached during the test.

Results from the Sequential Chemical Extraction (SCE) procedure indicate that large fractions of the cadmium, copper, lead and zinc present in the three types of fly ash are potentially available for leaching under acidic leaching conditions. Conversely, most of the aluminum, antimony, chromium and nickel present in all four types of

ashes are not potentially available for leaching. Both the SCE and SBEP results show that greater fractions of most metals in the fly ashes, compared with those in the bottom ash, are available for leaching.

Results from the Ontario Regulation 309 Leach (Reg 309) test indicate that all four types of ash would be considered hazardous if they were subject to Reg 309. Regulatory limits were exceeded for cadmium and lead in almost all the fly ash leachates, and for lead in the bottom ash leachate. However, substantial modifications were made to the incinerator operating conditions during the fall of 1988. Preliminary indications from further tests are that much better "burnout" of the refuse is occurring and the bottom ash would now meet Reg 309 criteria for a non-hazardous waste (Victoria Hospital Corporation, 1989).

The results from this study show a large difference between the leachability of the bottom ash and fly ashes. The highly soluble fly ashes contain much higher concentrations of toxic metals than the fairly insoluble bottom ash. It would be advisable to collect the bottom ash and fly ash separately to facilitate treatment of the fly ash prior to disposal.

5.0 RECOMMENDATIONS

Based on the results from this study, it is recommended that;

1) Further research be conducted on the physical and chemical processes involved in "fouling" in heat recovery units. This would provide valuable information in terms of characterizing the chemical and leaching properties of the ashes from these units.

2) Combined fly ash from the boiler, economizer and CT/FF units be treated prior to disposal. Treatment techniques such as solidification or metal removal should be evaluated.

3) A study be conducted to characterize the existing municipal solid waste stream for metals such as cadmium and lead. Identification of the major sources of these metals may promote either source separation of specific constituents in the waste stream or lead to regulations which stipulate use of alternative less toxic substances in the manufacturing of these materials.

ACKNOWLEDGEMENTS

This study was funded by Environment Canada and the Waste Management Branch of the Ontario Ministry of the Environment. The co-operation of the London Victoria Hospital Energy-From-Waste facility and FENCO Ltd. is gratefully acknowledged. The professional support and laboratory services provided by Environment Canada's Urban Activities Division, Wastewater Technology Centre and River Road Environmental Technology Centre are also gratefully acknowledged. Technical assistance for this study was provided by R. Foggett from the Ontario Ministry of the Environment, and by M. Hobbs and D. Walch from the Wastewater Technology Centre.

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APPENDIX I

INCINERATOR PROCESS DATA EVALUATION

BY

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CONSERVATION AND PROTECTION
URBAN ACTIVITIES DIVISION

The incinerator investigated in this report is the London Victoria Hospital Enegy-from-Waste facility located in London, Ontario. The incinerator consists of three "Consumat" units each rated to burn 90.9 tonnes of municipal waste every 24 hours. The design is based on the two-stage combustion principle. The main characteristic of this design relates to the burning of garbage in the primary chamber under sub-stoichiometric air (i.e.shortage of air) conditions. This results in a relatively low temperature combustion process and produces carbon monoxide and other combustible gases. These gases pass into the secondary combustion chamber where they are mixed with additional combustion air and are burned under excess air conditions. A temperature of 982°C (design) is maintained for a gas residence time of one second, to maximize the destruction of any noxious compounds. After the hot gases leave the secondary chamber, they pass through a refractory-lined duct to the heat recovery steam generator (HRSG) or "boiler". These boilers, one for each incinerator, are rated to produce 9525 kg/hr of steam at 4481 kPa and 346°C, from feed water at 140°C. The flue gas leaves the economizer at a temperature of approximately 215°C (design). The gas enters a conditioning tower where water is sprayed into the gas to reduce its temperature to approximately 135°C (design). The cooled gases then enter a vertical, up-flow reactor which consists of a venturi in a duct. A controlled quantity of powdered lime is added to the gas in the venturi. The flue gases, with the entrained lime, enter the pulse-cleaned baghouse filter. After passing through the coating of lime collected on the outside of the bags, the cleaned gas is discharged into the exhaust flue system. For a more complete description of the process, the reader should consult section 1 of this report.

This study was planned jointly by Environment Canada and the Ontario Ministry of the Environment (MOE) and took place during the week of April 4, 1988. The incinerator selected for the sampling program was Unit B. Prior to the test program, several process parameters of interest were identified. The two main parameters for assessing process stability were steam flow and secondary chamber temperature. At the end of each test run, LVH personnel provided a complete summary of the requested operating information.

Every effort was made by plant operators to maintain the operating conditions as stable as possible. Figure 1 through 4 illustrate the most important process parameters.

Figure 1 shows that, for the five days of sampling the secondary chamber temperature was constant at around 990°C , which is similar to the design temperature of 982°C . On the other hand,

the primary chamber temperature fluctuated anywhere between 640 and 920°C, with an average of around 760°C, during the 5 days of testing.

The boiler inlet and outlet temperatures over the 5 day period are plotted in Figure 2. Both temperatures were constant: the boiler inlet temperature averaged 870°C (design 871°C) and the outlet average was 340°C.

The various temperatures of the Air Pollution Control system are reported in Figure 3. The average conditioning tower inlet and outlet temperatures were 230°C and 157°C respectively (design 215°C and 13[illegible]°C) and were fairly constant. The baghouse inlet temperature averaged 150°C with no significant variation.

For all temperatures recorded for the Air Pollution Control system, the averages do not vary significantly from design values. The only exception is for conditioning tower outlet temperature; the average is 22°C higher than design. This difference may be important since the critical temperature zone for condensation of mercury is around 170°C to 180°C.

Figure 4 shows the steam flow variation for the 5 days of testing. The fluctuation in the steam flow is normal for this kind of technology but would be considered to be significant for a mass burning incinerator. The steam flow averaged 9000 kg/hr which is slightly lower than the design value (9525 kg/hr).

Figure 5 illustrates the amount of garbage that was processed during the 5 days of testing. Each load of garbage was weighed and recorded by the crane operator. The average amount of garbage processed was constant at around 3.0 metric tonnes per hour or 72 metric tonnes per day. This represent only 79% of design capacity (90.9 metric tonnes per day).

According to maintenance information, the lime addition system was not working properly prior to the test. The system was repaired and a person from the maintenance company was on site during the first 3 days of sampling. On the fourth day, the lime addition system began to malfunction resulting in increased lime injection rates. The ash changed from a grey colour to an almost white colour and significantly greater quantities of ash were collected.

FIGURE #1

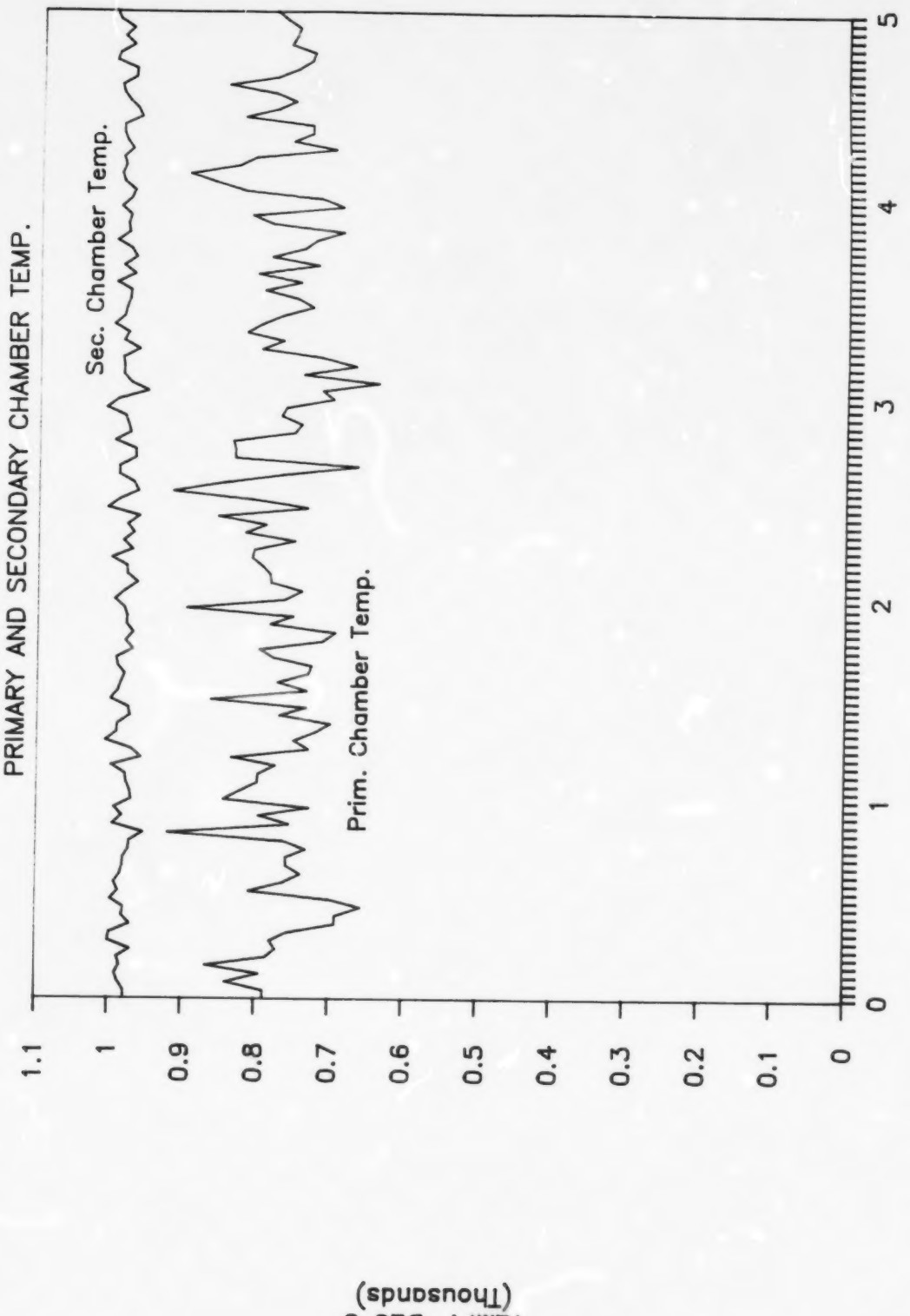

PRIMARY AND SECONDARY CHAMBER TEMP.
Sec. Chamber Temp.
Prim. Chamber Temp.
TEMP. DEG C
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
DAYS

FIGURE #2

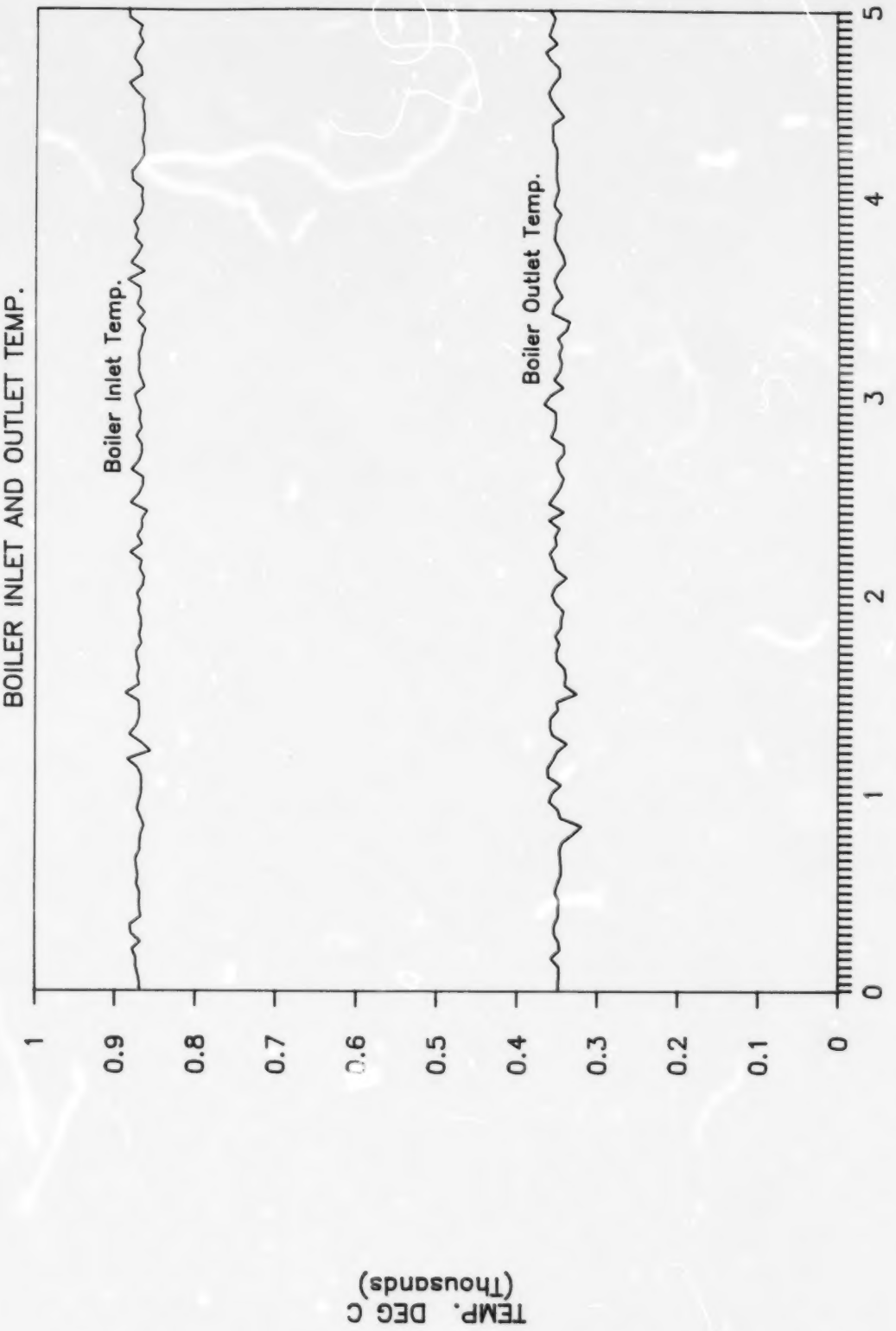

BOILER INLET AND OUTLET TEMP.
Boiler Inlet Temp.
Boiler Outlet Temp.
TEMP. DEG C
(Thousands)
DAYS
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5

FIGURE #3

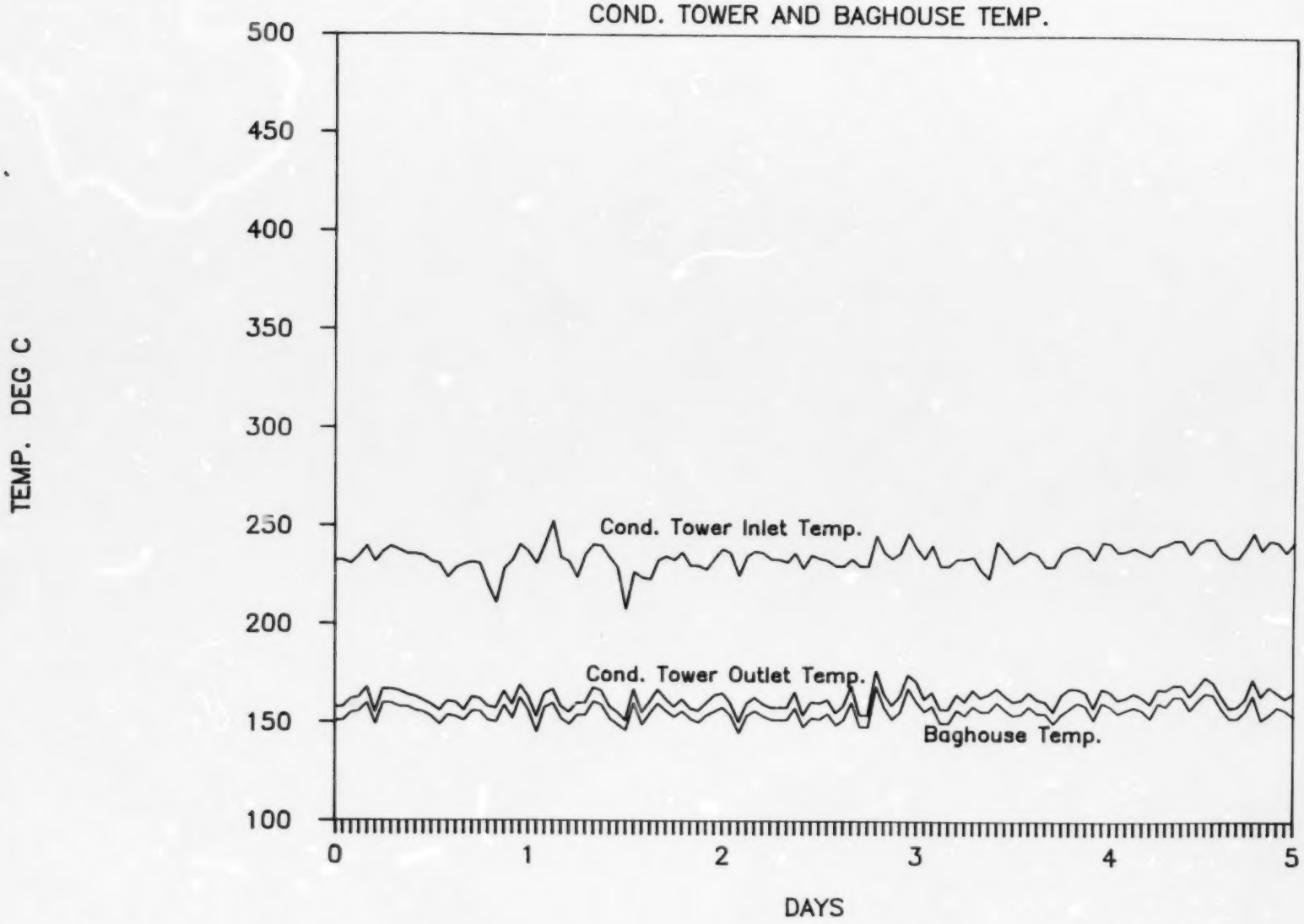

COND. TOWER AND BAGHOUSE TEMP.
TEMP. DEG C
500
450
400
350
300
250
200
150
100
0
1
2
3
4
5
DAYS
Cond. Tower Inlet Temp.
Cond. Tower Outlet Temp.
Baghouse Temp.

FIGURE #4

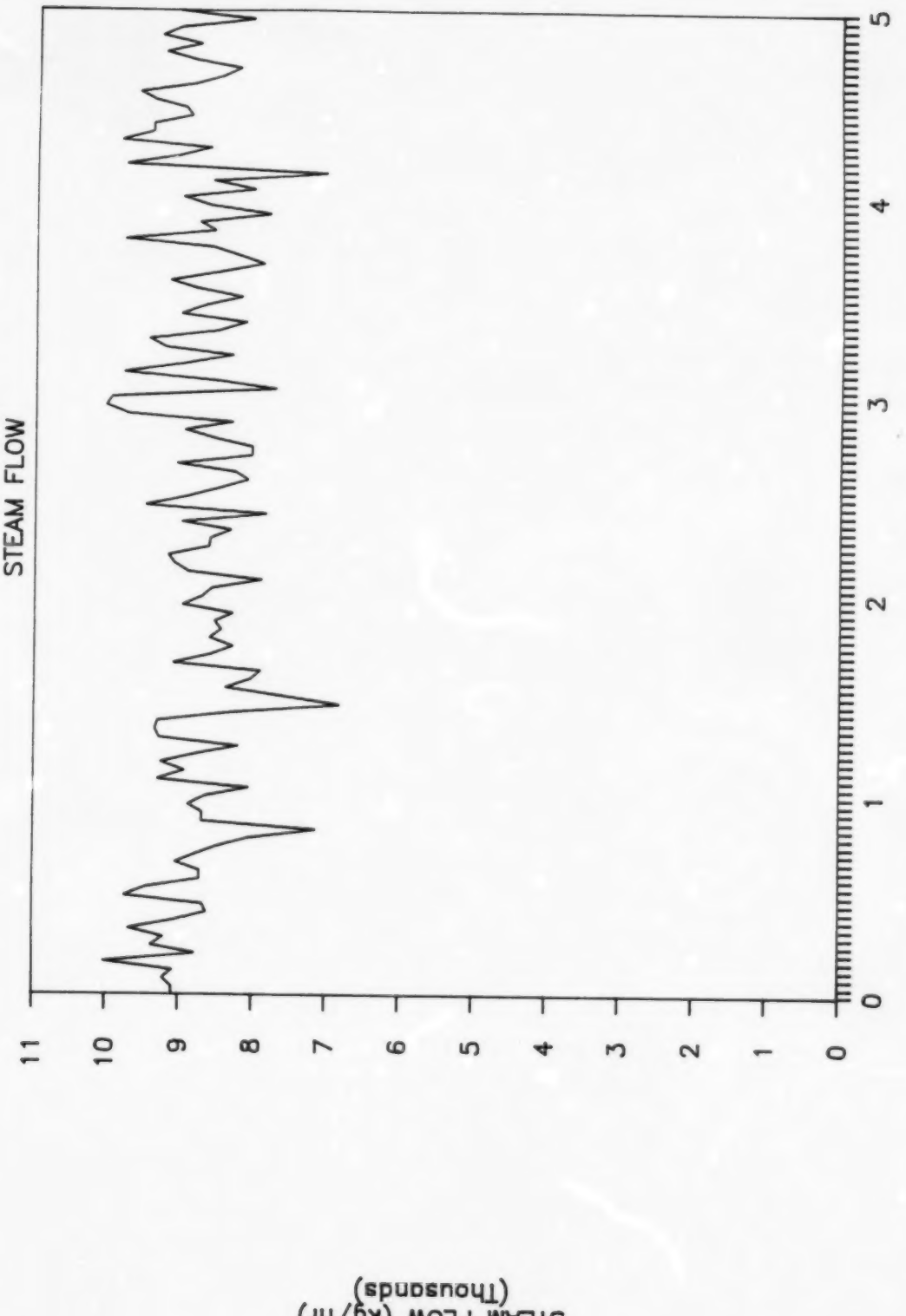
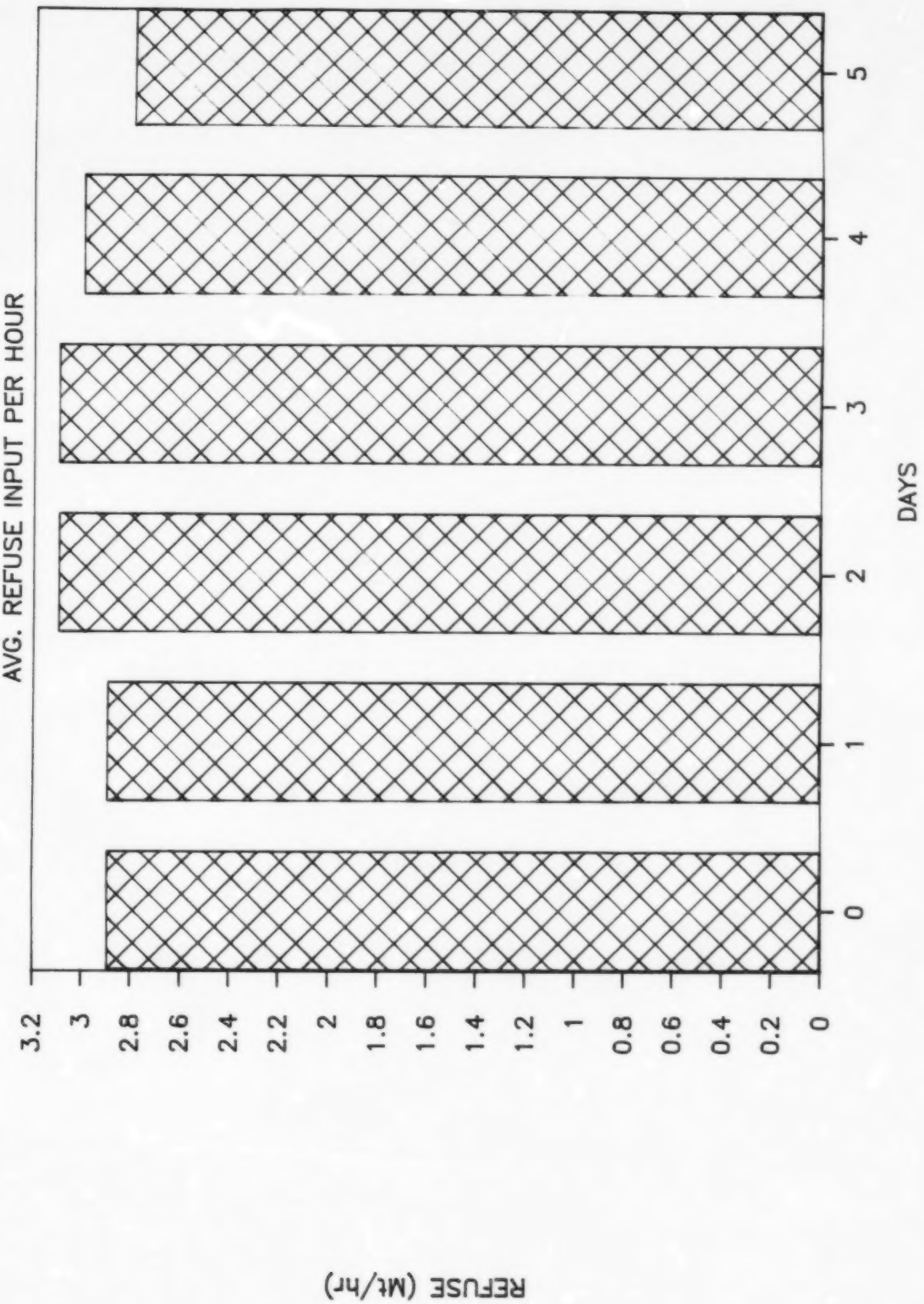

STEAM FLOW
STEAM FLOW (kg/hr)
(Thousands)
11
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
DAYS

FIGURE #5


AVG. REFUSE INPUT PER HOUR
REFUSE (Mt/hr)
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
DAYS

APPENDIX 2
DETAILED TEST RESULTS

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP, LONDON VICTORIA HOSPITAL
ANALYTE: DIOXIN/FURAN, ng/g
SAMPLE TYPE: ASH
CODE: NI_DX02_28/06/88

SAMPLE ID	LVH-891 BOILER ASH	LVH-892 ECONOMISER ASH	LVH-935 ASH	LVH-93 BOTTOM A
SAMPLE SIZE	2.5g	2.5g	2.5g	2.5g
T4CDD	- (0.12)	0.88 (0.11 /4)	1.25 (0.10 /8)	- (0.05
P5CDD	- (0.32)	2.43 (0.29 /2)	3.60 (0.26 /4)	- (0.14
H6CDD	1.93 (0.23 /3)	33.54 (0.21 /6)	15.67 (0.21 /6)	- (0.12
H7CDD	6.98 (0.23 /2)	60.71 (0.20 /2)	14.86 (0.19 /2)	- (0.14
OCDD	70.81 (0.20 /1)	175.25 (0.20 /1)	24.70 (0.20 /1)	- (0.20
TOTAL PCDD	79.72	272.81	60.07	-
T4CDF	0.49 (0.12 /4)	4.51 (0.11 /9)	14.23 (0.10 /12)	- (0.04
P5CDF	1.06 (0.16 /3)	10.68 (0.15 /9)	12.28 (0.13 /10)	- (0.07
H6CDF	7.16 (0.23 /4)	23.02 (0.21 /6)	13.92 (0.21 /8)	- (0.08
H7CDF	19.30 (0.23 /2)	37.86 (0.20 /3)	9.90 (0.19 /4)	- (0.10
OCDF	6.06 (0.20 /1)	11.58 (0.20 /1)	2.62 (0.20 /1)	- (0.14
TOTAL PCDF	34.07	87.65	52.95	-
RECOVERY %				
13C12-T4CDD	82	91	104	128
13C12-P5CDD	94	103	114	142
13C12-H6CDD	88	96	97	121
13C12-H7CDD	86	98	105	104
13C12-OCDD	99	101	100	74
13C12-1234TCDD	120	111	127	129

Note:(1) Results are corrected for surrogate recovery.
(2) Numbers in brackets represent detection limit/ number of isomers (or peaks resolved).
(3) "-" denotes values below detection limit (ng/g/analyte peak).

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP, LONDON VICTORIA HOSPITAL
ANALYTE: PAH, ug/g
SAMPLE TYPE: ASH
CODE: NI_PAH02_23/06/88

SAMPLE ID	LVH-891 BOILER ASH	LVH-892 ECONOMISER ASH	LVH-935 ASH	LVH-938 BOTTOM ASH
SAMPLE SIZE	2.5g	2.5g	2.5g	2.5g
Acenaphthylene	-	-	-	-
Acenaphthene	-	-	-	-
Fluorene			-	0.113
Phenanthrene	0.014	0.046	0.026	0.804
Anthracene	-	-	-	0.211
Fluoranthene	-	0.037	0.035	0.270
Pyrene	-	0.018	-	0.320
B(a)A	-	-	-	0.081
Chry/Trip	-	0.015	-	0.129
B(b)F	-	0.054	-	0.101
B(k)F	-	-	-	-
B(e)P	-	0.014	-	0.046
B(a)P	-	-	-	0.046
Perylene	-	-	-	-
IP	-	-	-	-
D(ac)A/D(ah)A	-	-	-	-
B(ghi)P	-	-	-	0.018
TOTAL PAH	0.014	0.184	0.061	2.139
RECOVERY %				
d10-Acenaphthene	27	50	36	57
d10-Anthracene	35	61	46	85
d10-Pyrene	61	82	61	101
d12-B(a)A	61	79	52	99
d12-B(a)P	34	65	38	52
d14-D(ah)A	62	72	41	37
d12-B(ghi)P	61	71	41	28
d10-Fluoranthene	97	100	90	139

Note: "-" denotes values below Detection Limit of 0.004 to 0.01 ug/g.

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP, LONDON VICTORIA HOSPITAL
ANALYTE: CP, ug/g
SAMPLE TYPE: ASH
CODE: NI_CP02_24/06/88

SAMPLE ID	LVH-891 BOILER ASH	LVH-892 ECONOMISER ASH	LVH-935 ASH	LVH-938 BOTTOM ASH
SAMPLE SIZE	2.5g	2.5g	2.5g	2.5g
CL2-PHENOL	0.020	0.019	0.049	0.030
CL3-PHENOL	-	0.028	0.191	-
CL4-PHENOL	-	0.061	0.402	-
CL5-PHENOL	-	0.052	0.221	-
TOTAL CP	0.020	0.160	0.863	0.030
RECOVERY %				
13C6-CL2-PHENOL	96	92	96	88
13C6-CL3-PHENOL	74	90	94	86
13C6-CL5-PHENOL	81	102	106	111
d10-Fluoranthene	108	94	87	91

Note: "-" denotes values below Detection Limit of 0.006-0.012 ug/g/analyte peak.

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP,LONDON VICTORIA HOSPITAL
ANALYTE: CB/PCB, ug/g
SAMPLE TYPE: ASH
CODE: NI_PCB02_24/06/88

SAMPLE ID	LVH-891 BOILER ASH	LVH-892 ECONOMISER ASH	LVH-935 ASH	LVH-938 BOTTOM ASH
SAMPLE SIZE	2.5g	2.5g	2.5g	2.5g
CL3-CB	0.017	0.054	0.027	0.011
CL4-CB	0.020	0.105	0.045	0.005
CL5-CB	0.031	0.174	0.054	-
CL6-CB	0.194	0.441	0.052	-
TOTAL CB	0.262	0.774	0.178	0.016
CL1-PCB				
CL2-PCB	-	-	-	-
CL3-PCB	-	-	-	-
CL4-PCB	-	-	-	-
CL5-PCB	-	-	-	-
CL6-PCB	-	-	-	-
CL7-PCB	0.004	0.006	-	-
CL8-PCB	0.004	0.013	-	-
CL9-PCB	0.009	0.016	-	-
CL10-PCB	0.010	0.011	-	-
TOTAL PCB	0.027	0.046	-	-
RECOVERY %				
13C6-CL4-CB	26	74	74	87
13C6-CL6-CB	58	96	90	99
13C12-CL5-PCB	91	101	92	106
13C12-CL8-PCB	93	93	84	96
d10-Fluoranthene	106	103	96	107

Note: "-" denotes values below Detection Limit (ug/g/analyte peak)
of 0.004 for CB; 0.004-0.008 for PCB.

SAMPLE CODES FOR LVH-EFW ORGANIC LEACHATES

SAMPLE CODE	DESCRIPTION
LVH-65	Bottom Ash Composite Cycles 1-5
LVH-66	CT/FF Ash Cycle 1
LVH-67	CT/FF Ash Composite Cycles 2-5
LVH-68	Boiler Ash Composite Cycles 1-5
LVH-69	Economizer Ash Composite Cycles 1-5

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP
ANALYTE: Dioxin/Furan, ng/L
SAMPLE TYPE: LEACHATE
CODE: NI_DX12
DATE: 29/09/88

SAMPLE ID	LVH-65	LVH-66	LVH-67	LVH-68	LVH-69
SAMPLE SIZE (L)	0.504	0.502	0.501	0.501	0.501
T4CDD	- (0.48)	- (0.50)	- (0.51)	- (0.45)	- (0.44)
P5CDD	- (0.76)	- (0.80)	- (0.78)	- (0.66)	- (0.61)
H6CDD	- (0.83)	- (0.89)	- (0.94)	- (0.77)	- (0.70)
H7CDD	- (0.99)	- (1.05)	- (1.01)	- (0.93)	- (0.80)
OCDD	- (1.08)	- (1.11)	- (1.07)	7.83 (1.02/1)	2.28 (0.88/1)
TOTAL PCDD	-	-	-	7.83	-
T4CDF	- (0.36)	- (0.37)	- (0.38)	- (0.34)	- (0.32)
P5CDF	- (0.48)	- (0.51)	- (0.50)	- (0.42)	- (0.39)
H6CDF	- (0.49)	- (0.53)	- (0.56)	0.46 (0.46/1)	- (0.42)
H7CDF	- (0.45)	- (0.48)	- (0.46)	4.52 (0.42/1)	- (0.36)
OCDF	- (0.90)	- (0.93)	- (0.89)	0.85 (0.85/1)	- (0.73)
TOTAL PCDF	-	-	-	5.83	-
RECOVERY %					
13C12-T4CDD	98	94	92	104	108
13C12-P5CDD	99	94	96	113	123
13C12-H6CDD	95	89	84	102	113
13C12-H7CDD	106	100	104	113	132
13C12-OCDD	99	96	100	105	122
13C12-1234TCDD	85	85	99	99	108

NOTE: (1) Results and Detection Limits are corrected for surrogates recovery.
(2) Numbers in brackets represent Detection Limit per peak/number of peaks detected.
(3) "-" denotes values below Detection Limit (ng/L/analyte peak).

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP
ANALYTE: CB/PCB, ug/L
SAMPLE TYPE: LEACHATE
CODE: NI_CB11
DATE: 29/09/88

SAMPLE ID	LVH-65	LVH-66	LVH-67	LVH-68	LVH-69
SAMPLE SIZE (L)	0.504	0.501	0.501	0.500	0.500
CL3-BENZENE	0.01	0.04	-	0.10	-
CL4-BENZENE	0.02	0.02	0.02	0.20	-
CL5-BENZENE	-	-	-	0.22	-
CL6-BENZENE	-	-	-	1.34	0.04
TOTAL CB	0.03	0.06	0.02	1.86	0.04
CL1-BIPHENYL	-	-	-	-	-
CL2-BIPHENYL	-	-	-	-	-
CL3-BIPHENYL	-	-	0.02	-	0.06
CL4-BIPHENYL	-	-	-	-	-
CL5-BIPHENYL	-	-	-	-	-
CL6-BIPHENYL	-	-	-	-	-
CL7-BIPHENYL	-	-	-	-	-
CL8-BIPHENYL	-	-	-	-	-
CL9-BIPHENYL	-	-	-	-	-
CL10-BIPHENYL	-	-	-	-	-
TOTAL PCB	-	-	0.02	-	0.06
RECOVERY %					
13C6-CL4-BENZENE	90	98	98	100	6
13C6-CL6-BENZENE	88	85	76	76	53
13C12-CL5-BIPHENYL	97	104	97	95	82
13C12-CL8-BIPHENYL	90	103	107	124	108
d10-Fluoranthene	90	92	87	83	81

Note: (1) "-" denotes values below Detection Limit (ug/L/analyte peak)
of 0.01 for CB; 0.01 - 0.02 for PCB.

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP
ANALYTE: CP, ug/L
SAMPLE TYPE: LEACHATE
CODE: NI_CP11
DATE: 29/09/88

SAMPLE ID	LVH-65	LVH-66	LVH-67	LVH-68
SAMPLE SIZE (L)	0.504	0.501	0.501	0.500
CL2-PHENOL	-	-	-	-
CL3-PHENOL	-	-	-	-
CL4-PHENOL	-	-	-	-
CL5-PHENOL	-	-	-	-
TOTAL CP	-	-	-	-
RECOVERY %				
13C6-CL2-PHENOL	111	129	106	132
13C6-CL4-PHENOL	109	128	106	132
13C6-CL5-PHENOL	114	134	110	124
d10-Fluoranthene	94	100	95	124

Note: (1) "-" denotes values below Detection Limit of 0.015 ug/L/analyte peak.

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP
ANALYTE: CP, ug/L
SAMPLE TYPE: LEACHATE
CODE: NI_CP12
DATE: 29/09/88

SAMPLE ID	LVH-69
SAMPLE SIZE (L)	0.500

CL2-PHENOL	-
CL3-PHENOL	-
CL4-PHENOL	-
CL5-PHENOL	-
TOTAL CP	-

RECOVERY %

13C6-CL2-PHENOL	91
13C6-CL4-PHENOL	96
13C6-CL5-PHENOL	84
d10-Fluoranthene	101

Note: (1) "-" denotes values below Detection Limit of 0.015 ug/L/analyte peak.

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP
ANALYTE: PAH, ug/L
SAMPLE TYPE: LEACHATE
CODE: NI_PA11
DATE: 29/09/88

SAMPLE ID SAMPLE SIZE (L)	LVH-65 0.504	LVH-66 0.501	LVH-67 0.501	LVH-68 0.500
AL	-	-	-	-
AE	-	-	-	-
FL	-	-	-	-
MFL	-	-	-	-
PHE	-	-	-	-
AN	-	-	-	-
FLT	-	-	-	-
PY	-	-	-	-
B(a)FL	-	-	-	-
B(b)FL	-	-	-	-
MPY	-	-	-	-
B(ghi)F	-	-	-	-
B(a)A	-	-	-	-
C&T	-	-	-	-
MB(a)A	-	-	-	-
B(b)F	-	-	-	-
B(k)F	-	-	-	-
B(e)P	-	-	-	-
B(a)P	-	-	-	-
PER	-	-	-	-
MCH	-	-	-	-
IP	-	-	-	-
D(ah)A	-	-	-	-
B(b)C	-	-	-	-
B(ghi)P	-	-	0.02	-
ANT	-	-	-	-
TOTAL PAH	-	-	0.02	-
RECOVERY %				
d10-AE	56	83	48	58
d10-AN	27	86	78	76
d10-PY	74	122	93	84
d12-B(a)A	72	119	92	94
d12-B(a)P	58	147	109	88
d14-D(ah)A	71	105	74	92
d12-B(ghi)P	83	119	92	92
d10-Fluoranthene	106	127	109	101

Note: "-" denotes values below Detection Limit of 0.01-0.02 ug/L/analyte peak.

ORGANIC LAB REPORT
ANALYTICAL SERVICES DIVISION
RRETC

PROJECT: NITEP
ANALYTE: PAH, ug/L
SAMPLE TYPE: LEACHATE
CODE: NI_PA12
DATE: 29/09/88

SAMPLE ID	LVH-69
SAMPLE SIZE (L)	0.500
AL	-
AE	-
FL	-
MFL	-
PHE	-
AN	-
FLT	-
PY	-
B(a)FL	-
B(b)FL	-
MPY	-
B(ghi)F	-
B(a)A	-
C&T	-
MB(a)A	-
B(b)F	-
B(k)F	-
B(e)P	-
B(a)P	-
PER	-
MCH	-
IP	-
D(ah)A	-
B(b)C	-
B(ghi)P	-
ANT	-
TOTAL PAH	-
RECOVERY %	
d10-AE	75
d10-AN	82
d10-PY	89
d12-B(a)A	94
d12-B(a)P	81
d14-D(ah)A	92
d12-B(ghi)P	92
d10-Fluoranthene	98

Note: "-" denotes values below Detection Limit
of 0.01-0.02 ug/L/analyte peak.

LVH-EFW Sequential Batch Extraction Results

Sample Type	Rep	Cycle	pH (units)	Cond (mS/m)	TDS (g/L)	SO4 (ppm)	Cl (ppm)	Metals (ug/ml) Al	As	B	Cd	Co	Cr	Cu	Ni	Pb	Sb	Zn
Bottom Ash (Solid)			10.15	-	-	-	-	40370	2.9	149	<5.00	288	430	1127	506	1971	71.8	6280
	1	1	10.45	1.52	0.60	331	241	46.00	0.002	0.356	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.500	<0.050
		2	10.52	0.54	0.30	98	26	25.00	0.002	0.300	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.500	<0.050
		3	10.71	0.33	0.40	20	<1	8.00	0.000	0.149	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.500	<0.050
		4	10.79	0.26	0.40	<1	<1	3.80	0.004	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.500	0.100
		5	10.89	0.18	0.30	32	<1	0.94	<0.002	0.374	<0.050	<0.050	<0.050	<0.050	<0.050	4.770	<0.500	0.500
	2	1	10.26	1.49	0.40	320	220	47.00	0.002	0.300	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.500	<0.050
		2	10.33	0.48	0.30	97	28	28.00	0.002	0.300	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.500	<0.050
		3	10.46	0.27	0.30	25	<1	11.50	0.003	0.101	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.500	<0.050
		4	10.65	0.22	0.30	14	<1	5.30	0.003	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.500	0.100
		5	10.75	0.18	0.30	<1	<1	0.97	<0.002	0.288	<0.050	<0.050	<0.050	<0.050	<0.050	5.330	<0.500	0.600
Boiler Ash	(Solid)		5.70	-	-	-	-	30110	125.6	116	788	44.8	385	675	156	23830	494	40260
	1	1	6.49	18.30	22.90	12000	357	0.64	0.004	0.650	36.400	0.090	<0.050	0.550	0.380	2.900	<0.500	847.000
		2	6.81	4.59	2.20	2770	17	0.42	0.002	0.358	4.670	<0.050	<0.050	<0.050	<0.050	2.300	<0.500	67.300
		3	7.27	2.21	1.10	1580	<1	0.34	<0.002	0.244	0.796	<0.050	<0.050	<0.050	<0.050	0.800	<0.500	10.200
		4	7.48	2.05	0.90	1720	<1	0.33	<0.002	0.194	0.300	<0.050	<0.050	<0.050	<0.050	0.460	<0.500	2.420
		5	7.59	1.96	1.00	1340	<1	0.42	0.002	0.116	0.265	<0.050	<0.050	<0.050	<0.050	0.619	<0.500	2.300
	2	1	6.40	18.80	19.70	12700	254	0.64	0.005	0.593	33.100	0.100	<0.050	0.670	0.530	2.800	<0.500	812.000
		2	6.74	4.53	2.40	2580	17	0.41	<0.002	0.339	4.420	<0.050	<0.050	<0.050	<0.050	2.200	<0.500	75.000
		3	7.28	2.37	1.50	1480	<1	0.32	<0.002	0.224	0.723	<0.050	<0.050	<0.050	<0.050	0.800	<0.500	8.400
		4	7.46	1.99	1.00	1440	<1	0.38	<0.002	0.136	0.300	<0.050	<0.050	<0.050	<0.050	0.620	<0.500	2.400
		5	7.58	1.97	1.20	1410	<1	0.42	<0.002	0.088	0.210	<0.050	<0.050	<0.050	<0.050	0.640	<0.500	2.200
Economizer Ash	(Solid)		7.40	-	-	-	-	33454	87.5	162	763	32.5	286	603	179	24009	627	35009
	1	1	7.52	16.00	12.80	5356	3086	0.73	0.002	1.880	14.500	<0.050	<0.050	<0.050	0.100	2.530	<0.500	61.300
		2	7.77	3.23	2.00	1650	191	0.30	0.002	0.250	1.270	<0.050	<0.050	<0.050	<0.050	0.870	<0.500	5.180
		3	7.91	2.37	1.70	1460	32	0.32	<0.002	<0.050	0.650	<0.050	<0.050	<0.050	<0.050	0.490	<0.500	1.830
		4	8.34	1.96	1.70	1420	<1	0.32	<0.002	<0.050	0.269	<0.050	<0.050	<0.050	<0.050	0.390	<0.500	0.552
		5	8.59	2.03	1.40	1620	12	0.38	<0.002	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.300	<0.500	0.230
	2	1	7.45	16.00	13.00	5010	2680	0.78	0.002	1.670	15.900	<0.050	<0.050	<0.050	0.090	3.120	<0.500	71.500
		2	7.74	3.30	2.10	1800	198	0.30	<0.002	0.170	1.370	<0.050	<0.050	<0.050	<0.050	0.750	<0.500	6.690
		3	7.95	2.36	1.60	1540	28	0.29	<0.002	<0.050	0.785	<0.050	<0.050	<0.050	<0.050	0.540	<0.500	2.370
		4	8.15	2.09	1.20	1490	10	0.28	<0.002	<0.050	0.422	<0.050	<0.050	<0.050	<0.050	0.460	<0.500	1.140
		5	8.59	2.03	1.50	1350	<1	0.39	0.002	<0.050	0.140	<0.050	<0.050	<0.050	<0.050	0.320	<0.500	0.340
CT/FF Ash	(Solid)		11.60	-	-	-	-	17200	97	150	821	13.5	187	627	46.7	13420	1093	38500
	1	1	11.50	30.00	28.40	2313	12700	0.24	0.005	0.900	<0.050	<0.050	<0.050	<0.050	<0.050	224.000	<0.500	3.000
		2	11.32	5.57	2.20	1720	1015	0.69	0.002	0.450	<0.050	<0.050	<0.050	<0.050	<0.050	22.300	<0.500	0.700
		3	11.15	2.87	1.10	2010	63	0.50	0.003	0.238	<0.050	<0.050	<0.050	<0.050	<0.050	17.000	<0.500	0.500
		4	11.14	1.80	0.60	1072	13	0.77	0.003	0.915	<0.050	<0.050	<0.050	<0.050	<0.050	6.650	<0.500	0.500
		5	11.18	1.20	0.40	609	8	2.84	0.003	0.389	<0.050	<0.050	<0.050	<0.050	<0.050	1.500	<0.500	<0.050
	2	1	11.52	35.00	27.10	1890	13400	0.16	0.005	0.900	<0.050	<0.050	<0.050	<0.050	<0.050	224.000	<0.500	3.000
		2	11.33	5.50	1.80	1718	1022	0.44	0.003	0.450	<0.050	<0.050	<0.050	<0.050	<0.050	19.000	<0.500	0.500
		3	11.16	2.78	1.30	1419	65	0.50	0.003	0.227	<0.050	<0.050	<0.050	<0.050	<0.050	14.000	<0.500	0.600
		4	11.18	1.69	0.70	1523	17	0.78	0.003	0.680	<0.050	<0.050	<0.050	<0.050	<0.050	7.000	<0.500	0.500
		5	11.18	1.20	0.50	574	11	3.60	0.003	0.315	<0.050	<0.050	<0.050	<0.050	<0.050	0.600	<0.500	<0.050

Sequential Chemical Extraction Procedure

Sample	Fraction	Metal conc. (ppm) Al	Sb	Cd	Co	Cr	Cu	Ni	Pb	Zn
Bottom	Total	47788	0	0	282	401	818	473	2172	6465
	A	<5.0	<10	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	13
	B	8800	<10	<2.5	187	13	99	64	1111	2975
	C	11260	<20	<5.0	49	26	118	138	645	1790
	D	9978	<20	<5.0	33	42	490	178	298	803
	E	17750	<20	<5.0	13	320	111	93	118	884
Boiler	Total	27273	359	746	43	354	634	161	31578	41112
	A	<5.00	<10	247	<2.5	<2.5	21	6	131	2510
	B	1100	<10	399	19	12	263	12	10250	22570
	C	9756	<20	68	<5.0	14	84	26	16260	5357
	D	4787	<20	25	10	31	100	16	4620	2340
	E	11630	359	7	14	298	166	102	317	8335
Economizer	Total	26117	392	781	26	232	610	166	28610	39893
	A	<5.00	<10	382	<2.5	<2.5	<2.5	<2.5	40	235
	B	3250	14	340	9	19	293	21	23385	27665
	C	9706	28	38	<5.0	22	103	47	4314	4740
	D	5786	<20	15	10	32	131	25	786	3196
	E	7375	350	7	8	160	83	73	85	4057
CT/FF	Total	15270	919	792	0	166	579	42	14351	39701
	A	<5.00	<10	<2.5	<2.5	<2.5	<2.5	<2.5	130	24
	B	2750	20	750	<2.5	20	412	7	9150	29650
	C	6416	406	42	<5.0	27	76	7	2760	4800
	D	1764	54	<5.0	<5.0	13	46	8	2211	2494
	E	4340	439	<5.0	<5.0	107	45	21	100	2733

MOE Reg 309 Results

Sample Type	Rep	SO4 (ppm)	Cl (ppm)	Metals (ppm) Al	Sb	As	B	Cd	Co	Cr	Cu	Pb	Ni	Zn
Bottom	1	357	1750	1.10	<0.5	0.01	2.00	0.19	0.20	<0.05	0.71	6.48	0.85	63.60
	2	377	1900	1.48	<0.5	0.01	2.22	0.09	0.20	0.36	1.03	7.18	0.33	45.90
Boiler	1	13400	352	3.34	<0.5	0.03	1.60	45.40	0.27	<0.05	17.00	4.37	0.81	1384
	2	12400	264	2.74	<0.5	0.03	1.60	41.00	0.27	<0.05	15.20	3.92	0.94	1304
Economizer	1	4630	3500	0.19	60.50	0.01	4.30	28.00	0.23	0.18	11.60	30.90	0.68	1188
	2	4190	3730	<0.050	8.62	0.00	3.00	26.60	0.17	<0.05	3.26	7.77	0.46	996
CT/FF	1	1230	14800	0.92	<0.5	0.00	4.00	37.00	0.15	<0.05	4.46	23.80	0.12	1113
	2	1020	14200	0.91	<0.5	0.00	4.30	33.80	0.15	<0.05	2.08	19.30	0.05	1016

APPENDIX 3

ADDITIONAL REGULATION 309 TESTING OF ASH FROM LONDON'S VICTORIA HOSPITAL ENERGY-FROM-WASTE FACILITY

conducted by

Ontario Ministry of the Environment

Staff from the Ontario Ministry of the Environment (MOE) reviewed the preliminary results from the NITEP study of the ashes from London's Victoria Hospital Energy-From-Waste Facility (LVH-EFW) in the fall of 1988. Since the Ontario Regulation 309 (Reg. 309) Leachate Extraction Procedure results indicated that the bottom ash from the facility narrowly exceeded the leachate toxic regulatory threshold for lead, the MOE wanted to determine if the five day composite sample had been skewed by high levels of lead from a sample from a single day.

The Wastewater Technology Centre provided MOE with sub-samples of each of the daily composite samples collected for the NITEP study. A total of five samples of the bottom and fabric filter ashes, and two separate sub-samples of each of the boiler and economizer ashes were tested and analyzed.

Sub-samples of each of the NITEP daily composite samples of bottom ash were collected using a 10 cm diameter stainless steel soil sampler. Separate sub-samples of boiler, economizer and fabric filter ash were collected using a 1.5 cm diameter glass tube. The Laboratory Services Branch of MOE then subjected each of the ash sub-samples to the Leachate Extraction Procedure and the resulting leachates were analyzed for the parameters listed in the Tables 1, 2 and 3.

The leachate samples were analyzed using Ontario Ministry of the Environment Standard Methods which may be obtained from the Laboratory Services Branch of the MOE.

The results from the test conducted on the sub-samples of bottom ash indicated that none of the parameters measured exceeded the regulatory limit provided in Reg. 309 (Table 1). This was in contrast to the results from the NITEP study in which the lead concentrations in the leachates were slightly higher than the 5.0 ppm limit stipulated in Reg. 309.

Results from the Leachate Extraction Procedure on the boiler, economizer and fabric filter fly ashes are presented in Tables 2 and 3, respectively. With the exception of the lead concentrations in the leachate from the boiler ash, these results indicate that all three types of fly ash produced leachates which exceeded the regulatory limit for cadmium and lead. These results are similar to those recorded in the NITEP study.

Part of the difference between the NITEP and MOE results on the bottom ash samples may be attributed to the heterogeneity of the material. In addition, it is

speculated that because the samples were stored for a period of six months under humid conditions prior to the MOE testing, some of the lead may have re-speciated, for example to lead carbonate or lead sulphate which is less soluble at a pH of 5 (the pH used in the Leachate Extraction Procedure) than some other lead compounds such as lead chloride.

It is not known if this re-speciation of the lead would occur under landfill conditions and further study of this phenomenon is recommended.

TABLE 1, ONTARIO REGULATION 309 LEACH PROCEDURE RESULTS

mg/l	BOTTOM ASH DAY 1	BOTTOM ASH DAY 2	BOTTOM ASH DAY 3	BOTTOM ASH DAY 4	BOTTOM ASH DAY 5
Cu	0.85	0.65	0.60	0.66	7.9
Ni	0.33	0.29	0.30	0.10*	0.27
Pb	0.59	1.1	2.5	0.50	0.62
Zn	22.0	32.0	22.0	14.0	35.0
Fe	0.20Δ	0.02Δ	0.22*	0.20Δ	0.20Δ
Mn	5.2	4.0	9.8	5.0	7.0
Al	1.7	2.1	7.0	1.6	4.4
As	0.004	0.007	0.006	0.004	0.008
Ba	0.71	1.2	1.6	1.6	1.8
Be	0.004Δ	0.004Δ	0.004Δ	0.004Δ	0.004Δ
Cd	0.17	0.059*	0.045*	0.045*	0.046*
Co	0.12	0.10*	0.078*	0.052*	0.099*
Cr	0.98*	0.099*	0.14	0.091*	0.11
Hg(ug/l)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mo	0.024*	0.044*	0.054*	0.044*	0.026*
Se	0.003	0.005	0.005	0.001	0.003
Sr	2.9	2.4	2.8	3.0	2.8
Ti	0.008Δ	0.008Δ	0.008Δ	0.008Δ	0.008Δ
V	0.02Δ	0.02Δ	0.02Δ	0.02Δ	0.02Δ

* MEASURABLE TRACE AFTER EXTRA DILUTION/CONCENTRATION

Δ NO MEASURABLE RESPONSE (DILUTION/CONCENTRATION):< REPORTED VALUE

TABLE 2, ONTARIO REGULATION 309 LEACH PROCEDURE RESULTS

mg/l

	BOILER	BOILER	ECONOMIZER	ECONOMIZER
Cu	12.0	3.9	2.2	4.6
Ni	0.73	0.77	0.22	0.24
Pb	2.44	2.13	14.0	49.8
Zn	1539	967	696	866
Fe	0.4*	0.2Δ	0.2Δ	0.2Δ
Mn	6.8	5.8	0.67	1.3
Al	4.0	0.63	5.8	15.0
As	0.78	0.045	0.002	0.008
Ba	0.08Δ	0.08Δ	0.08Δ	0.08Δ
Be	0.04Δ	0.04Δ	0.04Δ	0.04Δ
Cd	50.0	42.0	30.0	27.1
Co	0.25	0.2	0.12	0.14
Cr	0.23	0.84*	0.059*	0.68*
Hg(ug/l)	0.12	0.1	0.62	0.77
Mo	0.12	0.073*	0.08*	0.074*
Se	0.001	0.003	0.028	0.019
Sr	0.37	0.3	1.2	0.80
Ti	0.031*	0.008Δ	0.008Δ	0.008Δ
V	0.020Δ	0.020Δ	0.020Δ	0.020Δ

* MEASURABLE TRACE AFTER EXTRA DILUTION/CONCENTRATION

Δ NO MEASURABLE RESPONSE (DILUTION/CONCENTRATION): < REPORTED VALUE

TABLE 3, ONTARIO REGULATION 309 LEACH PROCEDURE RESULTS

mg/l	FLY ASH DAY 1	FLY ASH DAY 2	FLY ASH DAY 3	FLY ASH DAY 4	FLY ASH DAY 5
Cu	3.3	0.39	2.3	0.48	0.42
Ni	0.08*	0.089*	0.11	0.02Δ	0.02Δ
Pb	22.0	21.0	28.0	177.0	61.0
Zn	1116	527	1216	5.0	7.3
Fe	0.20Δ	0.20Δ	0.20Δ	0.20Δ	0.20Δ
Mn	2.7	1.9	2.3	0.071*	0.23
Al	2.2	2.5	2.1	7.8	20.0
As	0.002	< 0.001	< 0.001	0.004	< 0.001
Ba	1.6	1.5	1.5	1.6	0.72
Be	0.004Δ	0.004Δ	0.004Δ	0.004Δ	0.004Δ
Cd	42.0	42.0	41.0	0.075*	0.11
Co	0.12	0.13	0.14	0.06*	0.02Δ
Cr	0.038*	0.074*	0.065*	0.040*	0.020Δ
Hg(ug/l)	16.0	20.0	16.0	19.0	21.0
Mo	0.064*	0.096*	0.088*	0.65	0.22
Se	0.006	0.002	0.019	0.008	0.016
Sr	2.8	2.7	2.7	2.4	2.9
Ti	0.008Δ	0.008Δ	0.008Δ	0.008Δ	0.008Δ
V	0.02Δ	0.02Δ	0.02Δ	0.02Δ	0.02Δ

* MEASURABLE TRACE AFTER EXTRA DILUTION/CONCENTRATION

Δ NO MEASURABLE RESPONSE (DILUTION/CONCENTRATION): < REPORTED VALUE